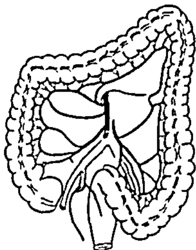


INTESTINAL OBSTRUCTION



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Preface

FOR MANY DECADES THE PROBLEMS posed by intestinal obstruction have captivated the interest of the entire medical profession. From the medical student to the scientist working in his laboratory, from the general practitioner, occupied with details of diagnosis, to the surgeon engaged in technical corrective measures, all must, either through design or through necessity, acquire some knowledge of this disease.

The practicing surgeon, to whom the responsibility of the care of patients with obstruction is entrusted, is the individual who is most deeply and intimately concerned with its various manifestations. In teaching hospitals many of the duties involved rest upon the shoulders of the resident staff. It is to all of these clinical surgeons that this book is addressed.

Numerous conferences, discussions, and teaching rounds have indicated that there are three particular subjects which the young surgeon must consider. They are:

1. What are the salient facts about intestinal obstruction? Although an imposing amount of fundamental information has been published, its abundance may excite confusion rather than lead to clarification. Medical literature contains thousands of papers on intestinal obstruction, many of which are valuable, either because of originality or because they present the most recent or complete discussions that are available. However, many articles are repetitious or are now chiefly of historical interest. Hence, in the interest of clarity and brevity, data have been selected and an encyclopedic collection of all available material has been avoided deliberately in this book.

2. What are the exact technical methods of management of specific types of obstruction? It is apparent that any attempt to compress a concept of a treatment of obstruction into a cookbook formula would be impossible and unwise. Blind routine cannot be substituted for surgical judgment; yet good

judgment can be negated by inattention to, or lack of knowledge of, the exact techniques involved in the indicated surgical procedures.

3. Where may further facts be obtained? Any reader who is interested in a particular facet of obstruction wishes to know more than can be furnished by a small text. For that reason the bibliography becomes an important guide to further information and other references. Therefore, insofar as possible, the most informative and readily available material has been cited.

From the historical point of view, it should be noted that intestinal obstruction has provided a focal point of interest in the Massachusetts General Hospital for over half a century. Scudder, Richardson, McIver, and McKittrick, as well as many others, have made important contributions to the knowledge of this disease. The main attention has been focused continually upon the clinical problem that is presented by the individual patient. Meanwhile, independence of thought has been promoted, so that individual opinion is not repressed, though it occasionally may be at variance with that generally accepted by other members of the surgical staff. In this text the author has designated those areas in which individual points of view, either from this hospital or elsewhere, have been substituted for generally accepted surgical opinions.

All students of intestinal obstruction will recognize the enormous debt that is owed, not only to our clinical teachers, but also to many other outstanding pioneers, such as Gamble and Wangensteen. This book, therefore, is presented with due humility, since it must include a recapitulation of the contributions of others. Thanks are also given to Mrs. Muriel McLatchie Miller for the illustrations; to Dr. Laurence L. Robbins, Chief of the Department of Radiology of the Massachusetts General Hospital, for a number of illustrations and helpful advice; to Dr. Richard Schatzki, Chief of Radiology of the Mount Auburn Hospital, for several radiographs; to Dr. Leland S. McKittrick for suggestions and criticisms; to Dr. Wm. C. Quinby for advice on pediatric surgery; to Miss Mary Sullivan and Miss Olive Dingle for aid in preparation of the manuscript, and, above all, to the surgical residents of our hospital who have devoted so much time and thought to the care of these patients.

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Historic Milestones

THE TREATMENT OF INTESTINAL OBSTRUCTION before the year 1800 was essentially the same as that used for constipation. Sporadic cures of the disease had been secured by the use of forcible enemas or by the oral administration of mercury, while multiple percutaneous punctures of the distended colon sometimes had prolonged life.

In 1713 Littre suggested the possibility of proximal decompression of the bowel by direct incision. This was not accomplished, however, until Pillore, in 1776, successfully made a cecostomy for the relief of obstruction due to cancer of the rectum. This operation was demanded by the patient despite the fact that six surgical consultants advised against it. The patient died less than a month later from necrosis of a jejunal loop caused by 2 pounds of mercury that he had swallowed a month before the operation.

Duret performed the first successful sigmoidostomy in 1793, but little enthusiasm was encountered until Amussat, in 1839, found, after careful anatomic studies, that a colostomy could be made in the left lumbar area without entering the peritoneal cavity. He advised its routine use for cancer of the rectum. For several decades thereafter "Amussat's operation" was employed frequently.

Meanwhile, studies of the methods of suture of lacerated intestine were progressing. It is possible that traumatic wounds of the colon may have been sutured by Lanfrancus about the year 1300, and he apparently understood that peritoneal surfaces of the intestine should be held together by suture until healing occurred. For centuries thereafter fecal fistulas must have been comparatively common because of traumatic lacerations of the bowel and operations for strangulated hernias. Nevertheless, suture of the intestine demanded little attention until Travers, in 1813, published an extensive mono-

graph of clinical and experimental studies proving the necessity of serosal sutures to maintain continuity. He showed that mucosal eversion was the cause of failure. Lembert's suture, the first of a long list of sutures to accomplish this purpose, still is known to every surgeon. It was described by him in 1826 and first used in the human being by Dieffenbach in 1836.

Another early contribution was a resection of the rectum by Lisfranc, leaving an uncontrollable perineal colostomy stoma. In 1833 Reybard carried out a resection and anastomosis for cancer of the colon.

Anesthesia and asepsis were necessary before any more significant progress could be made. Late in the last century numerous contributions appeared, setting the pattern for the technical details still followed today. A lag in appreciation of physiologic principles meant that progress was greater in the field of colonic surgery than in that of the small intestine. For obstruction of the colon two modes of therapy evolved—that of resection and primary anastomosis and that of obstructive resection. By 1892 Bloch was able to collect reports of 138 cases in which cancer of the colon had been treated surgically, and added three of his own. He proved that exteriorization was a far safer operation at that time than primary anastomosis. Paul, in 1895, apparently without any knowledge of Bloch's work, came to similar conclusions. This method of resection was advocated by Mikulicz and later perfected by Rankin. It frequently has been known since by Rankin's term—"obstructive resection."

Primary resection and anastomosis of the colon meanwhile had lost favor. Murphy had introduced his button method of anastomosis in 1892, but it was not until 1908, when Parker and Kerr introduced the principle of aseptic anastomosis, that this method again became safe. Since that time innumerable variations of aseptic suture and clamps to facilitate the procedure have been described.

Within the last two decades there has been a wide and nearly universal trend toward resection and primary anastomosis of the unobstructed colon and a similar, but slower, swing away from "aseptic" to open anastomosis. Extension of these principles to the obstructed, nonprepared colon still must be accepted with some qualifications.

Technical progress in surgery of obstruction of the small intestine lagged far behind. Jejunostomy was recommended by Fuhr and Wisener in 1886. This procedure remained essentially the sole method in the surgeon's armamentarium for the treatment of simple obstruction due to adhesions and bands for nearly a half century. It reached the height of popularity in the decade 1920-1930, when it was agreed generally that the operation was useful when simple obstruction was present but valueless in the presence of strangulation or paralytic ileus.

Fortunately, adjuvant measures for the treatment of obstruction were being developed. Hartwell and Hoguet instituted a new era when they discovered in 1912 that the lives of dogs with high intestinal obstruction could be prolonged by the subcutaneous injection of saline solution. Numerous other laboratories have contributed to this field, in which Gamble and associates have made outstanding additions to our knowledge.

The wide use of enterostomy as a surgical technique had introduced many new complications and failed so frequently that Wangensteen's popularization of constant suction to an inlying gastroduodenal tube came in 1933 as a major advance. Tubes had been used sporadically before that time. A stomach tube had been employed for feeding by John Hunter in 1790 and by Physick to wash out a stomach in 1813. Einhorn and Gross described their duodenal tubes in 1910, and the Levin tube appeared in 1921. Siphonage drainage of the stomach in cases of intestinal distention was introduced by Westerman in 1910, and the application of continuous suction to duodenal tubes by Ward in 1925. In the succeeding years many surgeons employed intermittent siphonage or suction for a variety of conditions, such as peritonitis or distention. Finally Wangensteen and Paine proved the superiority of suction, and after the successful use of suction by Wangensteen in the treatment of mechanical obstruction, the method became established. It is now used so commonly that it is almost impossible for the young surgeon to realize the desperate condition of patients with intestinal obstruction before the introduction of suction and adequate fluid replacement, or to appreciate the extreme importance of these contributions.

The long intestinal tubes were introduced by Miller and Abbott in 1934; others were described by Johnston in 1938, Harris in 1945, Cantor in 1946, and Grafton Smith in 1952.

The introduction of antibiotics also heralded a new era. Though clinical results have not been as impressive as experimental evidence, it is apparent that some advanced cases of obstruction are now amenable to surgical intervention that were nonsalvageable before.

Because of the simultaneous impact of improved operative methods; fluid, blood and electrolyte replacement; tubes, and antibiotics, the past decade has been one of stress and flux. Various clinics have tended to champion certain methods of treatment, though gradually some measure of agreement has been achieved.

This brief summary may be supplemented by the historical reviews of Allen on surgery of the colon, Colcock on colostomy, Shelley on enterostomy, and Paine on intestinal intubation.

2

Anatomy

A. SMALL INTESTINE

THE SURGEON MUST APPRECIATE the fact that the small intestine varies considerably in length, ranging from 12 to 22 feet. Normally the duodenum is about 1 foot long, the jejunum 7 to 8, and the ileum 10 to 12. The dividing line between jejunum and ileum is not sharp. Despite the fact that the jejunum tends to be above the umbilicus and the ileum below, and despite variations in the pattern of arterial arcades, accurate orientation in any case of obstruction is impossible until the surgeon identifies the ligament of Treitz and the ileocecal valve. Because of variations in the length of the bowel, both of these fixed points must be located before extensive resections are carried out. Except when anomalies of rotation are present, the second, third, and fourth portions of the duodenum are retroperitoneal and the remainder of the small intestine intraperitoneal. Normally the mesentery of the intestine is attached closely to the posterior abdominal wall, but occasionally there may be a complete lack of fixation, when the whole jejunum, the ileum, and sometimes the right, and very rarely the entire, colon are suspended only by a tiny pedicle that bears the superior mesenteric vessels.

B. LARGE INTESTINE

The anatomic divisions of the colon (cecum, ascending colon, hepatic flexure, transverse colon, splenic flexure, descending colon, and sigmoid colon) are easily identified. There is less agreement about nomenclature of the distal gut. In this book, in accordance with Gilchrist's definition, the rectum will be divided into two portions, the intraperitoneal and the extraperitoneal. The intraperitoneal begins at the point where the mesentery of the sigmoid disappears, approximately opposite the third sacral vertebra, and

extends down to the base of the pouch of Douglas. It is about 8 cm. in length and corresponds to the less precise term "rectosigmoid." It will be noted that the anterior wall at this section of the rectum is covered by visceral peritoneum, though the posterior wall is extraperitoneal. The extraperitoneal rectum extends from the base of the pouch of Douglas down to the anus. It is entirely extraperitoneal, and it also is about 8 cm. long.

Variations in the length and diameter of the colon are not uncommon. An unusually long colon is called a dolichocolon and is subject to volvulus. In megacolon, not only is the colon long but the diameter is greatly increased. The extent of the mesenteric fixation is also variable. Frequently the right colon is entirely free on a mesentery. On the other hand, the descending colon essentially always is firmly fixed to the lateral and posterior walls. The sigmoid is free on a mesentery in childhood, but often develops partial fixation later in life because of inflammatory adhesions.

C. BLOOD SUPPLY

The typical blood supply of the intestine and colon is shown in Figures 1 and 2. The duodenum is supplied by a mesenteric arch arising from the superior and inferior pancreaticoduodenal arteries, which originate, respectively, from the gastroduodenal and superior mesenteric. The right and transverse colons are also supplied through the superior mesenteric, via the ileocolic, right colic and mid-colic branches. The left colon receives blood from the inferior mesenteric by way of the left colic branch to the splenic flexure and descending colon and the sigmoid branches. The terminal portion of the inferior mesenteric, the superior hemorrhoidal, runs to the intraperitoneal rectum. The lower portion of the rectum depends upon the middle hemorrhoidal, from the hypogastric artery, and the inferior hemorrhoidal, from the internal pudendal.

Variations in the pattern of the major blood vessels supplying the colon are common. Several investigators, including Steward and Rankin and Basmajian, have shown the frequency of these anomalies. The ileocolic artery is always present. According to Steward and Rankin, the right colic artery was absent in 18 per cent of their specimens. It arose from the superior mesenteric in only 40 per cent; it came in 12 per cent from the ileocolic and in 30 per cent from the middle colic. The middle colic artery was absent in 5 per cent of the cases. In 10 per cent there was an accessory middle colic artery supplying the left side of the transverse colon. In all cases the artery began its course to the right, and usually only a part of one branch passed to the left of the median line of the body. There were usually only two branches of the artery but occasionally as many as four. The left colic artery was al-

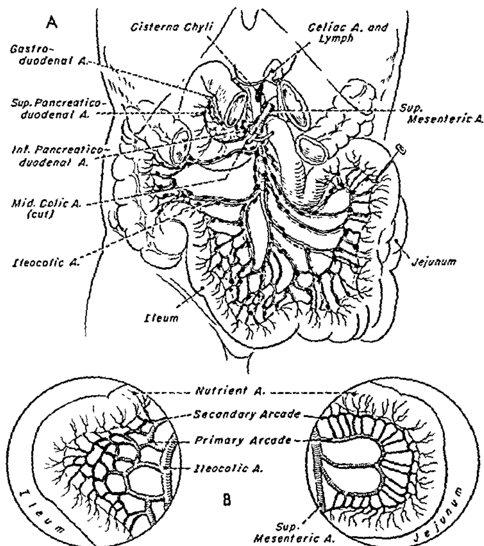


Fig. 1.—Blood supply and lymph nodes of small intestine. A, pancreaticoduodenal arch courses along inner-curve side of duodenum. Multiple branches of superior mesenteric artery supply jejunum and ileum. B, variations in arterial arcades in upper jejunum and lower ileum.

ways present but varied in its direction and extent. In 27 per cent of Steward's dissections the ascending branch of this artery did not extend as high as the splenic flexure, while in 63 per cent of the cases it passed above the flexure.

The sigmoid arteries are particularly variable, though this is of little practical significance. Usually there are two trunks, but there may be one to six

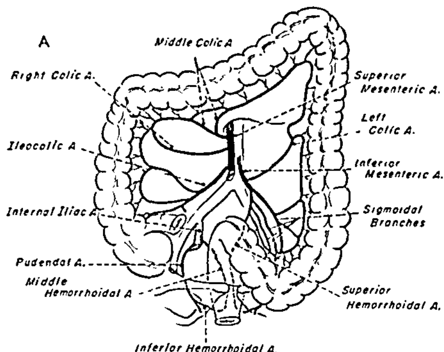
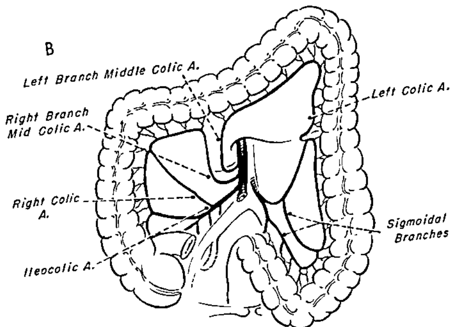


Fig. 2.—Blood supply of colon. A, usual distribution of arterial supply (continued).

such branches, which usually arise directly from the inferior mesenteric. However, the highest or all may originate from the left colic artery.

Fortunately the marginal artery provides an excellent anastomotic channel, so that interruption of the main arterial supply to a section of colon is not disastrous. The marginal artery is remarkably constant, though short sections may be absent. These defects are encountered most frequently low in the sigmoid and along the ascending colon. However, the marginal vessel is small and may easily be obliterated by tension or torsion.

The anatomy of the inferior mesenteric artery is of particular interest to the surgeon because it is ligated at its orgin and removed in many left colectomies. Dissections by Goligher and by Ault, Castro, and Smith, show that



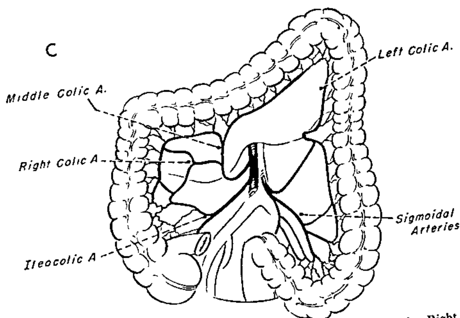


Fig. 2 (cont.).—**B,** some of common variations in arterial supply. Right colic artery arises from ileocolic. Mid-colic artery is double. Upper sigmoid artery arises from left colic. **C,** other common variations. Right colic artery arises from mid-colic. Left colic does not reach splenic flexure. Marginal artery is absent in ileocecal area and in mid-sigmoid.

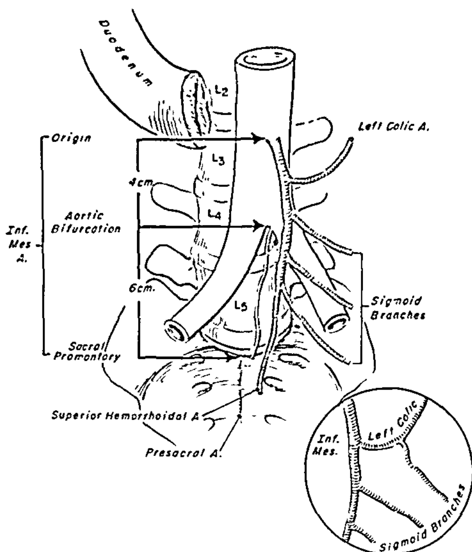


Fig. 3.—Anatomy of inferior mesenteric artery. Bifurcation of aorta is located on fourth lumbar vertebra. Origin of inferior mesenteric artery is 4 cm. above lower margin of bifurcation, and artery ends opposite sacral promontory, 6 cm. below. In insert, common variation of arterial supply is shown. First sigmoid branch arises from left colic artery.

this vessel usually arises from the aorta opposite the third lumbar vertebra, at a point about 10 cm. above the sacral promontory and 4 cm. above the aortic bifurcation. The left colic artery arises 3 to 4 cm. distal to the origin of the inferior mesenteric and the sigmoid branches 3 to 5 cm. beyond that point. As the artery crosses the sacral promontory it becomes the superior hemorrhoidal (Fig. 3).

The intrinsic blood supply of the small intestine consists of a profuse network of vessels. Noer has shown that anastomoses of the intramural vessels in the wall of the small intestine are numerous. He, with Derr and Johnston, demonstrated survival of short intestinal loops deprived of mesenteric blood supply when distention was prevented. The presence of these free anastomoses on the antimesenteric border of the small intestine has been confirmed by Rose; he quotes descriptions of cases in which 4, 3, and 3½ inches of intestine were separated from the mesentery by trauma but recovery occurred without resection after wrapping with omentuum. However, the colon does not have as adequate protection, since lateral anastomoses are relatively poor. The vasa longa of the colon, which run from the marginal artery just below the serosa, have infrequent anastomoses and are compromised if distention is acute, or they may be damaged by the surgeon if he carries out a rough dissection of the appendices epiploicae. On the other hand, there is no evidence, as Rose has shown, that the vasa longa actually run into the appendices, nor does torsion of an appendix epiploica ever produce gangrene of the adjacent colic wall. Hence, careful removal of the appendices will not harm the blood supply of the colon (Fig. 5).

It is apparent that the surgeon must be meticulous in his dissection, must be certain that there are pulsating vessels at the line of his anastomosis, and must not allow postoperative distention.

D. LYMPH NODES

Lymph nodes of the small intestine are located in the mesentery and are so numerous and closely connected that effective radical dissections are nearly impossible. In the colon, the nodes are divided into several well-defined groups. Epicolic nodes are tiny and are found closely apposed to the colon. Paracolic nodes are in the mesentery close to the colon at the level of the marginal artery. Intermediate nodes lie along the principal branches of the mesenteric vessels, and the primary nodes are in close proximity to the superior and inferior mesenteric arteries (Fig. 4).

E. NERVES

The nerve supply of the intestine and colon not only is of theoretical importance but has practical significance, since, in certain instances, clinical at-

tempts have been made to modify some of the symptoms of obstruction by nerve interruption. The intrinsic nerve supply has been described by White, Smithwick, and Simeone (Fig. 6).

The intestine is innervated by both the parasympathetic and the sympathetic system. The parasympathetics run from the dorsal vagal nuclei via the vagi and intrinsic visceral plexuses to terminate around the ganglion cells of

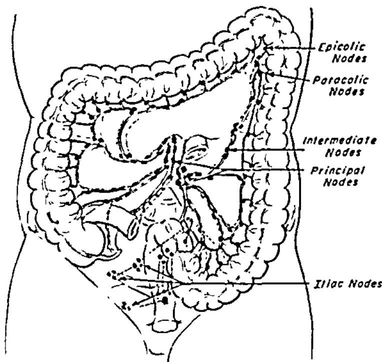


Fig. 4.—Lymph nodes of colon. Epicolic nodes are small, located on wall of colon. Paracolic nodes are found along course of marginal artery on mesenteric border of colon. Intermediate nodes are adjacent to main arterial branches of superior and inferior mesenteric arteries. Deep nodes are adjacent to superior and inferior mesenteric arteries.

Auerbach's myenteric and Meissner's submucous plexuses. They stimulate peristalsis and carry some afferent reflex stimuli and a portion of the sensation of nausea.

The sympathetic fibers originate from cells in the spinal cord, traverse the lower five to seven pairs of thoracic white rami, and pass through the sympathetic trunk ganglia, for the most part without interruption, and along the splanchnic nerves to end in the preaortic ganglia. Postganglionic fibers leave these ganglia to run with the vagal fibers along the periarterial visceral plexuses and from there to the intestine. The efferent pathways carry fibers

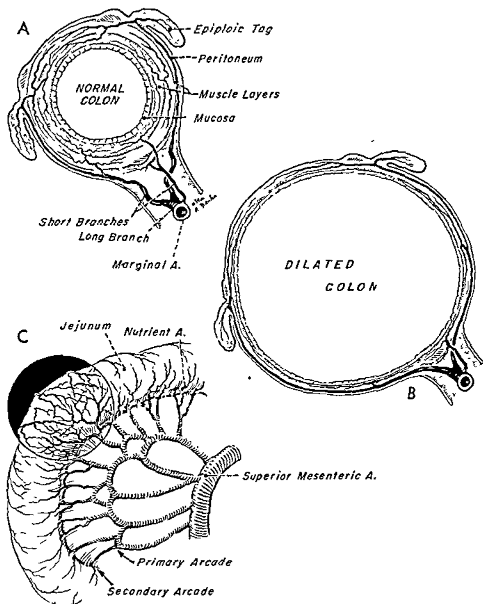


Fig. 5.—Intrinsic blood supply of colon and intestine. **A**, normal, nondistended colon. *Note vasa longa that run just below serosa to antimesenteric border and vasa* brevia that penetrate mesenteric wall of colon. Vasa longa run just below epiploic appendages. **B**, colon distended to diameter twice that in *A*. Circumference increases at rate $C = \pi D$. If original diameter is 2 cm. and that in *B* 4 cm., corresponding lengths of vasa longa are 6 and 12 cm. This is important reason why distention is not compatible with adequate blood supply in colon. **C**, intrinsic blood supply of small intestine according to Noer. Note multiple anastomoses in wall of intestine. Such anastomoses are not present in colon.

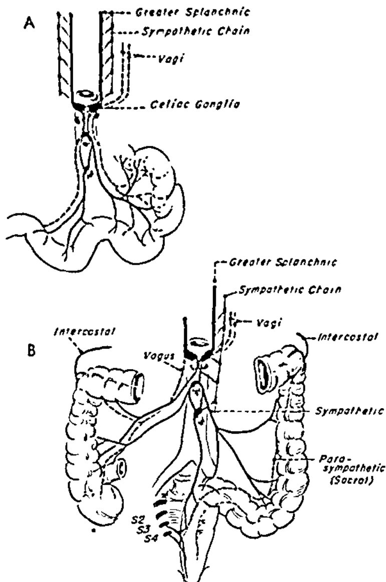


Fig. 6.—Nerve supply of small intestine and colon. A, small intestine. Sympathetic supply passes through thoracic ganglia 7 to 12 and via great splanchnic to celiac plexus. Fibers then pass through mesenteric plexus and along blood vessels to gut. Parasympathetic supply is via vagus, through celiac ganglia to mesenteric plexus and along blood vessels to intestine. B, colon. Sympathetic and parasympathetic supply are probably same as those of intestine as far distal as mid-transverse colon. Sympathetic supply of distal colon is via thoracolumbar outflow to celiac plexus and mesenteric ganglia along blood vessels to colon. Parasympathetic supply of distal colon is via nervi erigentes, which arise from S2 to S4. They ascend in wall of colon or its mesentery, but not along blood vessels, according to Lannon and Weller, as high as the mid-descending colon. Some of sensory supply of colonic flexures is mediated via intercostal nerves.

that inhibit peristalsis, stimulate secretion, and produce vasoconstriction. The afferent fibers carry subconscious reflex stimuli, the feeling of nausea, and the pain of distention from hollow viscera.

From a practical point of view, the nerve supply of the gut has been of interest to the surgeon if he has attempted to relieve some cases of chronic intestinal obstruction (*q.v.*) by nerve section. Since it has been difficult to influence motor activity of the gut, most operations have involved section of the afferent pathways. It has been established by balloon distention studies that thoracolumbar sympathectomy will abolish painful stimuli of distention from the small intestine but not from the colon. Interruption of the afferent supply to the colon has not been successful. Pain sensations from the rectum can be abolished by cutting sacral roots, but this leads to loss of voluntary micturition and loss of control of the anal sphincter. Probably, according to White and Sweet, both sympathetic and parasympathetic nerves of the colon carry afferent fibers, while some pain sensations about the flexures are transmitted by way of the somatic nerve supply.

The innervation of the colon is less well understood than that of the rectum. The parasympathetic supply has been described by Lannon and Weller. The lower portion is innervated via the sacral nerve roots, the nervi erigentes, and the wall or mesentery of sigmoid and descending colon. It is probable that vagus fibers innervate the proximal portion of the colon. The function of the parasympathetic is to contract the lower colon and control the anal sphincter.

The sympathetic supply arises from preganglionic cells of the lowest thoracic and upper lumbar portion of the cord. These cells send their axons out over the lower white rami of the thoracolumbar outflow to the lumbar and preaortic ganglia. Postganglionic fibers descend to the colon. Their function is to produce contraction of smooth muscle in the rectum and inhibit peristalsis in the lower colon.

3

Diagnosis

A. SYMPTOMS

INTESTINAL OBSTRUCTION MAY BE DEFINED as the failure of passage of the products of digestion along the intestinal tract.

The various types of obstruction are defined and classified in Chapter 4.

The diagnosis of acute intestinal obstruction usually is simple, though it may be exceedingly difficult. The examining surgeon must first establish the diagnosis of obstruction and then decide the probable cause, determine the area of involved bowel, and consider whether the obstruction is simple or strangulating in type. The signs and symptoms of intestinal colic, obstipation, vomiting, and abdominal distention are familiar to every medical student. However, all too often the diagnosis is not made in time to save the patient's life. The reasons for delay are numerous, but the main one is that the attending physician does not appreciate the fact that obstruction may be present when only one of these features is encountered, and he is awaiting the remainder of the quartet.

PAIN.—The most important symptom is pain. It is the earliest to appear and usually is so severe that it is dulled but not extinguished by morphine. Unless strangulation is present, it is colicky, occurring in waves that appear once every two to three minutes and last 15 to 30 seconds. Colic is observed typically in infants and young children, who may be quiet and playing happily between attacks but who scream with each spasm. In the same fashion, simple observation of patients who have been quieted by drugs may be enough to establish the diagnosis. They may complain of no pain, but regularly and almost rhythmically will grasp at their abdomens as the colic appears.

The location of the pain is highly significant, because, in the typical case, small-intestinal cramps are referred to the epigastrium and colonic to the

lower abdomen. If the patient is asked to locate the site of his pain, he may be unable to answer, but if he is told to place his hand where he feels it, the site will be identified accurately. However, variations in the location of the pain occur. Thus, either small- or large-intestinal obstruction may cause generalized abdominal cramps. Pain from an obstructed colon may be felt anywhere along the course of the distended bowel and particularly over a distended cecum. Likewise, both types of obstruction may produce pain in the back. Such pain arising from the small bowel is more frequent in the upper lumbar area, while that from the sigmoid or rectum may be felt in the perineum.

Steady abdominal pain when due to intestinal obstruction indicates strangulation. This pain may appear after a long period of colic, as the blood supply to the affected loop gradually is obliterated, or may be severe and steady from the onset. *It is important to recognize the fact that steady abdominal pain may be the only sign of a gangrenous loop of intestine and that the laboratory studies and X-ray examination may be negative.* Therefore, intestinal obstruction should be considered in the differential diagnosis of every case of acute abdominal pain.

Though pain is such a prominent feature, it is possible for obstruction to exist in the absence of pain. A relative lack of pain may sometimes be noted when the obstruction occurs in the early postoperative period. In this case, attended by a clouded psyche, a full-fledged intestinal obstruction may be manifested by a patient who has demonstrated nausea or distention but who, because he has received opiates for discomfort due to the fresh incision, has never complained of pain. Partial obstruction, sufficient to produce nausea or diarrhea, may not cause pain. It also is of interest that pyloric or duodenal obstruction does not cause pain, while tumors or adhesions of the upper jejunum may obstruct without colic, since the short segment of intestine is decompressed by vomiting.

OBSTIPATION.—This is a second cardinal symptom. An old clinical teaching is that colicky abdominal pain and obstipation in the presence of an abdominal scar make the diagnosis of intestinal obstruction. Consequently the examiner must inquire carefully about the passage of gas or stool and the exact nature of any discharge. Gross bleeding noted either before the pain begins or soon afterward is extremely important in establishing the cause of the obstruction.

It must be recognized that obstipation is not necessary to establish the diagnosis. It is not uncommon to observe the discharge of feces after the onset of obstruction, particularly if enemas are given. Moreover, in certain instances of partial obstruction, there may actually be an increase in number of stools, though they tend to be watery and small in amount. The physician

must also remember that in certain instances a strangulating obstruction may develop in such a short time that gangrenous bowel is produced only a few hours after a normal movement.

VOMITING.—This also is a fairly reliable but not a constant symptom. The frequency of vomiting and the nature of the vomitus vary greatly, depending on the location of the obstruction. If the obstruction is in the intestine, reflex vomiting is noted at the onset. There is then a period of relative freedom, followed later by the appearance of small-bowel contents. If the vomitus contains large amounts of clear bile, the obstruction is near the ligament of Treitz. If it is feculent, the obstruction is at the level of the midjejunum or below.

When acute obstruction develops in the colon, vomiting rarely is noted as an early symptom. Progressive distention of the proximal colon occurs first, and it is not until the small bowel fills with air and fluid that the typical fecal vomiting appears; this may never occur if the ileocecal valve is competent. While fecal vomiting is nearly always diagnostic of intestinal obstruction, absence of this symptom does not rule out the diagnosis, particularly when the lesion is in the colon. Vomiting is not always encountered even when there is strangulating obstruction of the small intestine.

Feculent vomiting usually is due to mechanical intestinal obstruction but can follow paralytic ileus. However, it is not always a symptom of obstruction, as observed by Gaspar, Walls, and Kendig. In the absence of ileus, fecal vomitus is most unusual and indicates a gastrocolic fistula, coprophagy, or violent reverse peristalsis. In some instances it is associated with lesions of the central nervous system that are believed to affect the peristaltic activity of the bowel. Gaspar's patient, 81 years of age, surprisingly vomited a barium enema immediately after it was given. His intestinal tract was apparently normal except for diverticulosis of the terminal colon. A minor degree of mesenteric thrombosis was suspected to have caused the change in the normal intestinal gradient. Six months later the barium enema was repeated and no abnormal reflux was observed.

ABDOMINAL DISTENTION.—Distention is a late but often a prominent symptom. Slowly developing pyloric obstruction may produce a huge stomach that fills the left side of the abdomen. High jejunal obstructions usually are not accompanied by significant distention. The longer the length of small bowel above the obstruction, the greater the distention. Huge symmetrical distention involving the entire peritoneal cavity occurs with late obstruction of the lower colon accompanied by an incompetent ileocecal valve. On the other hand, when the valve is competent, the outline of a greatly distended colon can be made out. Volvulus of the sigmoid may lead to a large visible distended loop.

lower abdomen. If the patient is asked to locate the site of his pain, he may be unable to answer, but if he is told to place his hand where he feels it, the site will be identified accurately. However, variations in the location of the pain occur. Thus, either small- or large-intestinal obstruction may cause generalized abdominal cramps. Pain from an obstructed colon may be felt anywhere along the course of the distended bowel and particularly over a distended cecum. Likewise, both types of obstruction may produce pain in the back. Such pain arising from the small bowel is more frequent in the upper lumbar area, while that from the sigmoid or rectum may be felt in the perineum.

Steady abdominal pain when due to intestinal obstruction indicates strangulation. This pain may appear after a long period of colic, as the blood supply to the affected loop gradually is obliterated, or may be severe and steady from the onset. *It is important to recognize the fact that steady abdominal pain may be the only sign of a gangrenous loop of intestine and that the laboratory studies and X-ray examination may be negative.* Therefore, intestinal obstruction should be considered in the differential diagnosis of every case of acute abdominal pain.

Though pain is such a prominent feature, it is possible for obstruction to exist in the absence of pain. A relative lack of pain may sometimes be noted when the obstruction occurs in the early postoperative period. In this case, attended by a clouded psyche, a full-fledged intestinal obstruction may be manifested by a patient who has demonstrated nausea or distention but who, because he has received opiates for discomfort due to the fresh incision, has never complained of pain. Partial obstruction, sufficient to produce nausea or diarrhea, may not cause pain. It also is of interest that pyloric or duodenal obstruction does not cause pain, while tumors or adhesions of the upper jejunum may obstruct without colic, since the short segment of intestine is decompressed by vomiting.

OBSTIPATION.—This is a second cardinal symptom. An old clinical teaching is that colicky abdominal pain and obstipation in the presence of an abdominal scar make the diagnosis of intestinal obstruction. Consequently the examiner must inquire carefully about the passage of gas or stool and the exact nature of any discharge. Gross bleeding noted either before the pain begins or soon afterward is extremely important in establishing the cause of the obstruction.

It must be recognized that obstipation is not necessary to establish the diagnosis. It is not uncommon to observe the discharge of feces after the onset of obstruction, particularly if enemas are given. Moreover, in certain instances of partial obstruction, there may actually be an increase in number of stools, though they tend to be watery and small in amount. The physician

timate of the patient's fluid and electrolyte balance must be made. Any dryness of the mucous membranes, dryness or wrinkling of the tongue, and loss of normal skin turgor indicate a depletion, which in a patient with intestinal obstruction is certain to mean deficiencies in both water and electrolytes. This depletion will be much greater than can accounted for by the amount of vomitus, since much fluid will have been excreted into the gut, where it is not absorbed and is lost to the body.

Careful pelvic and rectal examinations are essential, and sigmoidoscopy is necessary in cases in which large-bowel obstruction is suspected.

A low blood pressure and a rapid pulse occur only after there has been severe depletion from long-continued simple obstruction or when a gangrenous loop is present. The temperature tends to follow the pulse; with early simple obstruction it is normal, but dehydration or strangulation causes it to rise. If the patient appears very ill or demonstrates all the clinical features of shock, it is probable that strangulation is present.

C. LABORATORY STUDIES

The laboratory aids are much less significant in establishing a diagnosis than the clinical examination of the patient. They do, however, aid greatly in an appraisal of the site of the obstruction and its relative severity. The important examinations that are to be made include radiologic studies, electrolyte determinations, the white blood cell and differential counts, and studies of urine, gastric aspirate, and rectal discharge.

Blood.—The white cell and differential counts tend to be normal in early cases of obstruction. A moderately high count, for example 15,000 to 25,000 is more typical of strangulation and is accompanied by polymorphonuclear leukocytosis. Extremely high counts, for example 30,000 to 50,000, are highly suggestive of mesenteric thrombosis. While these are general trends, it must be emphasized that such studies alone are unreliable guides either to the diagnosis of obstruction or in the differentiation of the simple and strangulating types. Strangulation accompanied by a normal white cell count and an essentially normal differential count is not rare.

The hemoglobin determination and hematocrit level, in the absence of previous disease, are normal in early cases of obstruction. As dehydration develops, the hematocrit level rises.

Urine.—If the patient is dehydrated and cannot void, it is best to place him on constant drainage at once. Accurate observation of the urine output is essential in these ill patients, and since hourly determinations are often necessary, an inlying Foley catheter will answer many problems. The admission specimen of urine is examined particularly to rule out diabetes

B. PHYSICAL EXAMINATION

ABDOMEN.—Inspection of the abdomen gives a clue to establishing the site of obstruction as described above. Peristaltic waves are sometimes visible, though they may be observed in very thin patients even in the absence of obstruction.

Auscultation furnishes the most important information. With simple mechanical obstruction, peristalsis occurs in rushes, is high-pitched, and often has a watery or metallic character. The patient's cramps are usually timed perfectly with the audible peristaltic waves. Between cramps the abdomen usually is silent. This pathologic peristalsis is entirely different from the normal type, which is low-pitched and nearly continuous. Abnormal peristalsis similar to that encountered in obstruction may also be heard in certain instances of gastroenteritis.

If the abdomen is entirely silent, it is probable that strangulation is present. When obstruction is suspected, the silent abdomen demands laparotomy.

On palpation the presence or absence of tenderness or of any masses must be noted. It is most important to recognize that early acute obstruction in the absence of strangulation or peritonitis is not accompanied by abdominal tenderness. A common error made by many physicians is to exclude a surgical abdomen and therefore a diagnosis of intestinal obstruction when no tenderness is present; obviously no greater mistake could be made, and to *await tenderness is to await circulatory impairment or gangrene.*

A mild amount of tenderness is not uncommon with late simple obstruction. However, when marked tenderness is found, interference with the vascular supply of the bowel is present and strangulation is probable. Tenderness is at first localized over the infarcted loop of bowel but becomes generalized as a bloody peritoneal exudate develops or peritonitis supervenes. It is accompanied by localized pain on cough or on motion, just as in any other inflammatory process within the peritoneal cavity.

A palpable mass is a great aid to diagnosis. An obstructing cancer of the colon often can be felt on abdominal or rectal examination. A sausage-shaped mass is frequently found when there is a volvulus of the sigmoid. An enterocolic intussusception often produces a mass large enough to be noted somewhere along the course of the ascending or transverse colon. A loop of small intestine filled with fluid can sometimes be outlined by the examiner, and an infarcted loop of small bowel may produce a mass palpable anywhere in the peritoneal cavity.

GENERAL PHYSICAL EXAMINATION.—The general physical examination is also very important. Together with a notation of the usual features, an es-

pression should be inserted and the stomach aspirated before the patient is sent to the X-ray department. In some instances, for example in the case of a ruptured spleen, the gastric gas shadow is actually of advantage to the radiologist in his interpretation.

If a long intestinal tube is used, fluoroscopic manipulation can be carried out at the time of the original examination.

In the typical case the diagnosis of obstruction is made on the abdominal

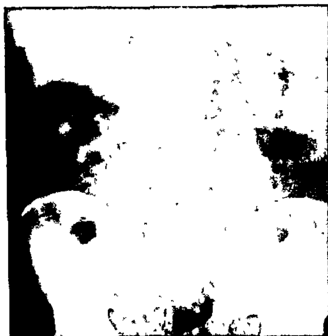


Fig. 7.—Small-bowel obstruction of four hours' duration. This 49-year-old patient had a tender irreducible umbilical hernia and had had periumbilical pain for four hours. At operation, dusky loop of intestine was found. Circulation returned after release of obstruction. Note that several loops of small bowel are already visible on X ray.

film by the presence of abnormal gas patterns, by fluid levels in the bowel, or by obstruction demonstrated by barium administration. In addition, the observer should note the presence or absence of intra-abdominal masses or fluid and retroperitoneal shadows. Films should be taken with the patient flat, erect, and in the lateral decubitus position, with the beam directed horizontally. These multiple positions may be necessary in order to obtain evidence of free air beneath the diaphragm and of fluid levels which usually are not visible with the patient in the horizontal position.

Gas and fluid levels.—With small-intestinal obstruction, gas as a rule

and urinary tract disease, since diabetic acidosis or renal colic can mimic intestinal obstruction. A large amount of albumin should raise the question of nephritis or uremia. The specific gravity will give a rough idea of the amount of dehydration, assuming that the kidneys are normal.

GASTRIC CONTENTS.—The gastric contents are obtained by aspiration as a gastric or long intestinal tube is passed. The presence of foul, brownish feculent fluid will establish the diagnosis without more ado. If the guaiac test is strongly positive, it is evidence in favor of strangulation while if the strangulated segment is high in the jejunum, the patient may have gross blood in the gastric aspirate or hematemesis. In many cases of obstruction, particularly when the lesion is in the colon, the stomach will be nearly empty.

A specimen of the rectal contents may be obtained either from the tip of a gloved finger or by enema. The presence of gross blood is often noted with ileocolic intussusception or with cancer of the colon. Normal fecal matter does not militate against the diagnosis of obstruction, since the intestine and colon distal to the obstruction are physiologically normal.

BLOOD CHEMISTRY.—Blood is drawn immediately for determination of sodium, potassium, chloride, carbon dioxide, nonprotein nitrogen, and, if necessary, blood sugar and amylase. These values are normal in early cases of obstruction but change as the disease progresses. They are essential guides in the formulation of therapy, particularly when the small bowel is involved. The interpretation of abnormalities in electrolytes will be considered later. A high nonprotein nitrogen level suggests renal damage or blood in the intestinal tract. The value for blood sugar may prove the existence of an unsuspected diabetes. The serum amylase may be elevated moderately with acute intestinal obstruction. As shown in experimental animals by Byrne and Boyd, this elevation is presumed to be due to back pressure in the duodenum and pancreatic ducts.

D. X RAY EXAMINATION

The X ray examination is by far the most important diagnostic procedure. It establishes the diagnosis of intestinal obstruction definitely in such a large percentage of cases that surgeons tend to rely entirely upon the radiologist for the diagnosis. However, the surgeon must recognize that there are certain limitations. Though the diagnosis can be made by this means in perhaps 90 per cent of the cases, strict reliance on this method is unwise. The utmost co-operation between radiologist and surgeon is necessary to obtain the best results.

If the patient probably has obstruction, the appropriate tube for decom-

strangulating obstruction of the small intestine is present, gas may never appear on the X ray, and in place of the usual fluid levels, the strangulated bowel may be represented by an opaque mass similar to that produced by an ovarian cyst. The similarity of the films in Figures 9 and 10 is striking.

Furthermore, there may be no accumulation of gas in the small intestine in certain instances of obstruction of the colon in which the ileocecal valve is competent and allows no reflux of colonic contents into the ileum. Here a

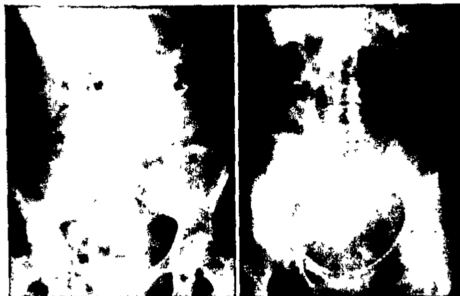


Fig. 9 (left).—Strangulating obstruction of small bowel. Large mass (indicated by arrows) rising out of pelvis represents *volvulus of small intestine*. Note small gas shadows within mass. Some gas is present in colon. Patient had complained of abdominal pain, and tender mass was palpable when this picture was taken, 24 hours after onset. (X ray, courtesy of Dr. R. Schatzki.)

Fig. 10 (right).—Paralytic ileus due to gangrenous ovarian cyst. Note close resemblance to Figure 9. There is large pelvic mass, with evidence of dilated small intestine above it. C-shaped loop (or "coffee bean") overlying lumbar vertebra is said to be characteristic of strangulating obstruction. Preoperative diagnosis, by both radiologist and surgeon, was strangulating obstruction. Immediate operation disclosed large gangrenous ovarian cyst. Recovery was uneventful. Patient was 79.

distended colon will be the only sign of obstruction, though gas and fluid levels can be encountered in it in the absence of obstruction after cleansing enemas. Such a competent valve is encountered in about 40 per cent of all patients who have barium enemas in our hospital, according to Robbins.

The absence of gas or fluid levels in the small intestine, therefore, may be interpreted in several ways. The patient may have a nonstrangulating obstruction, but of too short a duration to allow characteristic X-ray changes; he

begins to collect in the bowel within three hours. However, significant gas or fluid levels are not demonstrable regularly until about six hours have passed. Sample X rays of typical early obstructions are shown in Figures 7 and 8. At



Fig. 8.—Acute small-intestinal obstruction of six hours' duration. Patient, 40-year-old woman, had had hysterectomy 17 years before. She complained of severe epigastric cramps and vomiting of six hours' duration. Physical examination disclosed no tenderness, and peristalsis was hyperactive. X ray demonstrated small dilated loop of small intestine. At operation intestine was shown to be obstructed by adhesion in pelvis.

the end of 12 hours dilated bowel and/or fluid levels should be apparent in nearly every case of simple small-bowel obstruction. It is generally agreed that if they are not present by 12 hours the diagnosis of acute simple obstruction of the small intestine is unlikely, though with colonic obstruction, a longer period usually is required before fluid levels appear.

An important exception to the above rule must be emphasized. When a

of Andersen and Ringsted, of Wangensteen and Rea, and of Maddock, Bell, and Tremaine. Maddock found that gas accumulation developing during pyelography can be prevented by keeping the stomach empty by suction with a Levin tube. The swallowed gas normally has a rapid transit time and will often appear in the colon within 15 minutes. An example is shown in Figures 11 and 12. The patient, a child, had a normal X ray before pyelography, and eight minutes afterward had his intestine full of air.

In the absence of obstruction this swallowed air assumes characteristic



Fig. 13.—Paralytic ileus. Woman, aged 60, had had resection of terminal ileum and right colon eight days previously. Two days after removal of Levin tube she became moderately distended and nauseated. Peristalsis was decreased in amount and slightly high-pitched. X ray demonstrates gas in stomach, small intestine, and descending colon. Prompt recovery ensued after another 48 hours of decompression by Levin tube.

patterns. In the duodenum it may produce a fine pebbly, granular appearance suggestive of polyposis. In the jejunum and ileum the distended intestine forms a netlike design in which coils of intestine or fluid levels characteristically are not visible. Larger amounts of air will produce large distended loops that may be indistinguishable from those in the film of mechanical ileus.

Clinically, an extreme amount of air can accumulate within a very short period of time. Positive pressure anesthesia applied on a face mask may dilate the stomach so rapidly that the distended organ becomes easily visible

may have a strangulating obstruction; the obstruction may be in the colon, or he may have no obstruction at all. It is perhaps appropriate at this time to emphasize the fact that the clinical findings are of first importance and should be influenced by radiographic studies only when the latter are markedly different from those anticipated or when they are characteristic of an unsuspected lesion.

It is next necessary to inquire about the occurrence of gas in the normal

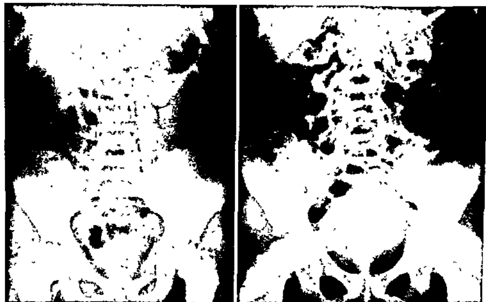


Fig. 11 (left).—Abdominal X ray of child taken immediately prior to intravenous pyelogram. Note gas in stomach, intestine, and colon; such small amounts are usually normal in children.

Fig. 12 (right).—*Child in Figure 11 eight minutes later, showing huge amount of* swallowed air in both small intestine and colon. Polyhedral shadows are typical of aerophagia, though larger amounts of swallowed air result in picture similar to that of acute mechanical obstruction. (Figs. 11 and 12, courtesy of Dr. R. Schatzki.)

abdomen. Gas is, of course, found constantly in the colon and usually in the stomach, and often a bubble can be demonstrated in the duodenal cap. In the small intestine gas is seen commonly in infants and children and occasionally in apparently normal adults. In none of these cases, however, should it be associated with fluid levels, except in the intestine as noted below, and in the colon after enemas.

A rapid accumulation of gas may be produced by air swallowing. This is noted particularly in children and in neurotic persons at times of stress. Frequently gas appears in the gut during the course of intravenous pyelography. That this air has been swallowed has been proved by the observations

Foreign bodies, gallstones, or fecaliths can sometimes be observed. Particularly careful attention is given to the region of the ureters, since renal colic may produce a severe ileus that closely mimics mechanical obstruction. Abnormal areas of calcification elsewhere should be noted; calcified mesenteric nodes, pancreatic calculi, and abdominal aneurysms may be seen. Above



Fig. 14.—Acute dilatation due to sprue. Man, 26, known to have sprue, complained of distention and abdominal discomfort. Note multiple dilated loops of intestine and fluid levels. Abdomen was nontender and peristalsis absent. Improvement followed intubation with Miller-Abbott tube. Patients with sprue occasionally have such episodes of acute obstruction that resemble mechanical obstruction.

all, the chest should be examined, as chest diseases may cause confusing findings in the abdominal film. Platelike areas of atelectasis in the lung bases follow abdominal distention. A pneumonitis, a dissecting aneurysm, or a pulmonary infarct may explain the cause of an ileus. Furthermore, a diaphragmatic hernia can sometimes be diagnosed on the chest film and indicate the cause of an obscure obstruction.

before a laparotomy incision can be made. Unless relieved by gastric aspiration, this air later passes into the intestine, producing the usual type of so-called postoperative ileus. When excess amounts of gas are present, and particularly when they accumulate rapidly, the state designated as "meteorism" exists.

After gas has remained in the intestine for some time, it may be followed by an outpouring of fluid, so that levels may be seen. This situation in its well-advanced form, when gas and fluid levels are seen indiscriminately in stomach, intestine, and colon, is the most typical finding in paralytic ileus. There are other radiologic characteristics that may serve to differentiate it from mechanical obstruction. Frimann-Dahl states that in paralytic ileus the distended loops are smaller, fluid levels shorter, and involved loops more curved in comparison with the ladder-like pattern of mechanical obstruction. Robbins, on the other hand, feels certain that the radiologist can rarely differentiate these two types of ileus by the X-ray film alone unless findings are absolutely typical of either mechanical or paralytic ileus (Fig. 13).

In a less marked degree, gas and fluid at times can be demonstrated in the normal intestine. For example, after an enema, multiple small bubbles of gas and fluid levels can be shown in the colon. In some instances of gastroenteritis, similar changes can be seen in both the intestine and the colon. Occasionally patients with severe constipation show these phenomena in the colon, and, in rare instances, when solid fecal matter is found in the ileum, the small intestine may be involved as well. In certain other deficiency diseases, such as sprue, a pseudo-obstruction with distended, fluid-filled loops of intestine is not uncommon; the cause of these changes is not known, but the clinical and radiologic picture may be identical with that of acute mechanical obstruction (Fig. 14).

Thus, gas and fluid levels in the small bowel, though they are highly suggestive of mechanical obstruction, may signify other conditions as well, including a variant of the normal, extreme aerophagy, paralytic ileus, gastroenteritis, severe constipation, and sprue.

Other findings on abdominal film.—Besides the presence of gas or fluid levels, the radiologist observes several other features. The presence of an abdominal mass visible upon the X-ray film may suggest a tumor but also raises the possibility of strangulated intestine full of fluid. The thickness of the intestinal wall can sometimes be estimated. Separation of adjacent loops of intestine or diffuse density in the pelvis may suggest the presence of a concomitant peritonitis, particularly if flank shadows are not outlined as clearly as usual. Free gas under the diaphragm will indicate a perforation of a hollow viscus. Demonstration of gas in the biliary tree is always abnormal and in the presence of intestinal obstruction suggests a gallstone ileus.

to be present, any examination must be carried out with great caution to prevent extravasation of barium through a perforation. Also, the introduction of a large amount of barium above an obstructing cancer that acts as a ball valve must be avoided if possible.

Barium by mouth.—In some instances, particularly in a subacute or chronic obstruction of the small intestine, a small amount of barium or other



Fig. 16.—Intestinal obstruction diagnosed by barium administered orally. Man, 80, had had subtotal gastrectomy eight years before. He had re-entered hospital several times for cramps and vomiting believed due to uremia. Diagnosis of obstruction was clarified immediately by gastrointestinal series, which shows great dilatation of stomach and afferent and efferent loops. Barium would not pass more than foot beyond gastric remnant. At operation, completely obstructing adhesion was cut.

contrast medium may be administered by mouth or through the tip of an intestinal tube. Urokon, a thinner medium, is quite suitable for this purpose, as advised by Canada. This method has definite value when obstruction is complete, since it proves that there is obstruction and often localizes it. Frequently it is of no value, but in some instances of high obstruction in which the diagnosis of obstruction is not clear, with high regional enteritis or, with some intermittently intussuscepting tumors of the right colon or small bowel,

EXAMINATION BY CONTRAST MEDIA.—The preliminary examination often must be followed by further X-ray investigations. These include intravenous urography, use of the barium enema, and occasionally administration of barium by mouth.

Barium enema.—The barium enema is given particularly in cases in which (1) the anatomy of the gas shadows is not clear on the plain film; (2)



Fig. 15.—Obstruction of colon. This diagnosis, suspected on basis of plain abdominal films, was proved by barium enema, which shows complete obstruction low in sigmoid. Because of complete block, nature of obstruction could not be determined from this examination. At operation cancer of sigmoid was found.

the diagnosis of large-bowel obstruction is not clear from plain film examinations; (3) the obstruction is known to be in the colon, but its exact type and location are not certain (Fig. 15); or in cases of intussusception in *which an attempt at reduction may be tried simultaneously.* Though the barium enema may give a great deal of information, certain drawbacks must be noted. If the enema is given as an emergency procedure, the preparation of the bowel may be far from satisfactory. It is possible to overlook an obstructing cancer of the left colon relatively easily in the presence of severe distention. When an inflammatory process, such as diverticulitis, is believed

to be present, any examination must be carried out with great caution to prevent extravasation of barium through a perforation. Also, the introduction of a large amount of barium above an obstructing cancer that acts as a ball valve must be avoided if possible.

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it may be valuable. A typical case in which it was most useful is shown in Figure 16.

Despite the worry by some surgeons about the safety of the careful small-bowel examination in the presence of obstruction, at the Massachusetts Gen-



Fig. 17.—Inaccurate localization of site of obstruction by X ray. Patient entered hospital with typical history of intestinal obstruction of 24 hours' duration. This plate was taken on admission. Single loop of distended small intestine is visible. Opinion of radiologist and surgeon was that this represented obstruction of mid-jejunum. Immediate operation disclosed cancer of mid-transverse colon. Primary resection and anastomosis plus cecostomy were followed by uneventful convalescence. Diagnosis of obstruction by X ray is easier than identification of exact site of block.

eral Hospital we have never seen any harm from use of barium in this fashion. The barium becomes mixed and thinned with the intestinal contents and consequently cannot be dangerous, as it may be in the colon, where proximal to an obstructing lesion it may produce huge fecaliths that are exceedingly difficult to remove. Experimental evidence secured by Donato, Mayo, and Barr confirmed the impression that peroral barium does not pro-

duce complete obstruction when introduced above a previously produced partial obstruction.

Comment.—From these studies with the radiologist, the surgeon should have a fairly accurate conception of the location and type of obstruction. Since in many instances it is impossible for the observer to decide whether or not distended loops on the scout film are small intestine or colon, the barium enema frequently becomes a part of the original examination. When

TABLE 1.—X-RAY DIAGNOSIS OF TYPES OF SMALL-INTESTINAL OBSTRUCTION*

	SIMPLE MECHANICAL OBSTRUCTION	STRANGULATION OBSTRUCTION	PARALYTIC ILEUS
Gas in intestine	Large hoop-shaped loops in ladder pattern	Few small bubbles or single loop	Diffusely scattered through intestine
Gas in colon	Little or none	Little or none	Diffusely present in scattered areas
Fluid levels	Definite	Often small and localized	Present; often very large
Tumor	None visible	Tumorlike opacity with multicircular outline	None visible
Peritoneal exudate	None	Present but may be hard to distinguish	Present with peritonitis; otherwise absent
Motion of diaphragm	Usually free	Usually diminished	Diminished

* This table, modified from Frimann-Dahl, must be interpreted with caution. It is descriptive but not diagnostic. The radiologist at the Massachusetts General Hospital, Dr. L. L. Robbins, is convinced that differentiation of the various types of ileus cannot be made by the X-ray film except when the X-ray and clinical impressions are unequivocally in agreement

manipulation of the tip of an intestinal tube into the duodenum is added, it is clear that the patient may face a long and exhausting stay in the X-ray room. Great care must be taken to be certain that as great expedition as possible be used, and, not infrequently, thorough X-ray studies must be omitted in the interest of early operation.

The surgeon must attempt to gain the greatest possible amount of information from the simplest examinations. Since the primary problem usually is to distinguish simple mechanical obstruction, strangulating obstruction, and paralytic ileus, the discussion above may be recapitulated by the inclusion of a table (Table 1), modified from Frimann-Dahl, to show the important features of differentiation.

Two final warnings should be given concerning the X-ray interpretation. First, the diagnosis of obstruction may be made but the localization may be

wrong. If a great deal of fluid collects above an obstruction, all of the gas may be pushed proximally, so that the obstruction is believed to be much higher than actually is the case. For example, in the case represented in Figure 17, an obstruction diagnosed by X ray as being at the level of the mid-jejunum was proved at operation to be located in the transverse colon, with enormous unsuspected dilatation of the right colon.

Secondly, the X ray may be negative but obstruction actually be present.



Fig. 18 (left).—Strangulating intestinal obstruction, with normal abdominal X ray. Boy, 18, had had ileostomy followed by colectomy for ulcerative colitis. Two years later he had acute onset of upper-abdominal cramps, nausea, vomiting, and complete obstipation. This X ray was taken when he entered hospital 48 hours later. Operation few hours thereafter showed volvulus about ileostomy with cyanotic but viable intestine. Recovery followed reduction of volvulus and closure of trap lateral to ileostomy. On plate there is only questionable evidence of intestinal obstruction, as shown by single dilated loop of small bowel.

Fig. 19 (right).—Intestinal obstruction was negative abdominal film. Patient had complained of abdominal cramps and vomiting of 10 days' duration. On film no dilated small intestine can be seen. Stomach, as indicated by arrows, however, is distended with fluid. At operation, cancer of ascending colon was found, with moderate distention of small intestine. (Courtesy of Dr. R. S. Shaw.)

This situation occurs most frequently with strangulating obstruction (Fig. 18) but may occur with simple obstruction (Fig. 19).

Perforation of colon by barium enema.—It should be recognized that there is a certain small percentage of cases in which perforation of the colon may occur during barium enema examination. Since some patients with

obstruction have perforated cancer or diverticulitis of the colon, the clinician must advise the radiologist that such a complication may be present, and he will then stop the procedure when any unusual signs are found. All efforts should be made to avoid introduction of barium into the peritoneal cavity. While perforation may occur through the normal colon, it is extremely rare. Kleinsasser and Warshaw demonstrated that the intracolonic pressure from an enema is 7.66 cm. of mercury. This is well below the level at which a normal colon perforates; this was established to be 21 cm. for the mucosa



Fig. 20.—Perforation of colon by barium enema. A, X ray taken soon after perforation. B, X ray taken two years later. Note that there has been no significant change in amount of barium in peritoneal cavity. Patient had had multiple attacks of intestinal obstruction secondary to dense adhesions.

and 18 cm. for the outer coats of the bowel and corresponds to a pressure of 4.07 and 3.49 pounds per square inch, respectively.

Small amounts of barium may escape from the lumen of the colon in the presence of a walled-off perforated diverticulitis or when a barium enema is given soon after a resection and anastomosis of the colon. This minimal extravasation does no harm. However, if by careless manipulation or because of disease of the colon, large amounts of barium are extruded into the free peritoneal cavity, immediate surgery is indicated to repair the rent and to remove as much of the foreign material as possible.

If barium is left in the peritoneal cavity, it causes infection and adhesions and may be eventually fatal. Our own experience has shown that perfora-

tion is a most unfortunate complication of a barium enema but can occur under most careful precautions.

Zheutlin, Lasser, and Rigler were able to prove the danger of perforation by barium enema. The over-all mortality rate was 51 per cent in 53 cases that they collected. Immediate surgery is necessary to remove any substantial amount of the extravasated barium sulfate. Survival is most likely if operation is carried out within three hours of perforation. Of patients who lived, clinically significant adhesions were found in 30 per cent of those who were followed for an average of 18 months.

That intraperitoneal barium is not absorbed is shown in Figure 20, where approximately the same amount is visible two years after it was introduced.

E. DIFFERENTIAL DIAGNOSIS

While simple mechanical intestinal obstruction may be confused with many diseases, the most important are acute gastroenteritis, pancreatitis, appendicitis, and renal or biliary colic. Strangulation obstruction may mimic many diseases that produce a combination of peritonitis and ileus; pancreatitis, appendicitis, and perforated duodenal ulcer are the commonest.

Acute gastroenteritis usually is heralded by severe intestinal colic accompanied by vomiting and followed by diarrhea. The characteristic vomiting and diarrhea may be delayed for several hours, and in this interval the clinical picture may be similar to that of acute mechanical obstruction. Hyperactive peristalsis occurs concomitantly with the cramps. However, the vomiting tends to be more frequent but less profuse than with obstruction, and the aspirate from the stomach never contains intestinal contents. The diagnosis is usually clear as soon as the profuse diarrhea begins. Very careful observation is necessary to rule out a partial obstruction, such as that due to Richter's hernia.

Acute pancreatitis and intestinal obstruction are often confused, since severe abdominal and back pain and repeated vomiting occur in both. Since pain from pancreatitis is steady, it is a strangulating small-bowel obstruction that must be differentiated. To establish the diagnosis of pancreatitis a high serum amylase is considered important; yet this level may be elevated with intestinal strangulation. Bloody fluid is present in the peritoneal cavity in both instances and may be found by a diagnostic tap. A single distended loop of small intestine or transverse colon is frequently seen on an abdominal film of a patient with pancreatitis. A high white cell count and essentially normal temperature may be present in both. If tenderness is marked and located over the pancreas, or if slight jaundice is present, the diagnosis of pancreatitis is fairly clear, but if the tenderness is lower in the abdomen



Fig. 21.—Strangulating obstruction diagnosed as pancreatitis. Case demonstrates difficulty of differential diagnosis in presence of strangulating obstruction. Man, 83, with severe and persistent abdominal pain beginning day before entry, collapsed shortly before he was brought to hospital. Past history was negative except for pneumonia several years before. Examination disclosed mottled cyanosis; fibrillation; boardlike abdomen with rebound tenderness and marked spasm, mostly in upper quadrant, and no masses; abdomen tympanitic throughout and no peristalsis; pulse 78, irregular; blood pressure 80/40; in urine, 3+ reaction for albumin and sediment containing 50 red cells, 20 white cells, and occasional granular cast; white cell count 7,300; hematocrit reading 39 per cent; nonprotein nitrogen 45 mg., calcium 4 mg. and on repeat examination 4.4 mg., fasting blood sugar 153 mg. per 100 cc.; sodium 140, potassium 4.4, chloride 102, and carbon dioxide 14 mEq. per liter; amylase 168 Russell units (*upper limit of normal, 40*). *Abdominal film demonstrated multiple distended gas*-filled loops of small intestine, with fluid levels. Some gas was present in colon, but it was not distended. Abdominal paracentesis yielded 25 cc. of serosanguinous fluid, with amylase 1,200 units. Because of abdominal findings and X ray somewhat more consistent with paralytic than with mechanical ileus, and particularly because of high amylase, low calcium, and high blood sugar, he was believed to have acute hemorrhagic pancreatitis. He was treated conservatively by suction therapy with transfusions of plasma and blood, but his condition rapidly declined, and he died six hours later. Autopsy revealed strangulated loop of ileum, 20 cm. in length, that was gangrenous. Ileum had been caught between adhesive band that extended from sigmoid across posterior wall of pelvis.

and particularly if an abdominal scar is present, intestinal obstruction may be the underlying disease. Early exploratory laparotomy may be the only way that differential diagnosis can be made (Fig. 21).

Acute appendicitis may be confused with intestinal obstruction. In the early phases of appendicitis, epigastric cramps may raise the question of obstruction. It is uncommon for pain due to appendicitis to be as severe as that from obstruction, and vomiting is a much less prominent symptom. The rapid development of localized tenderness and a low-grade fever usually resolve the question. However, a loop of strangulated ileum may produce the same clinical and laboratory findings as appendicitis.

Other diseases that produce colicky abdominal pain, and sometimes are mistaken for simple obstruction, are biliary colic, particularly when the stone is in the common duct, and renal colic. Torsion of an ovarian cyst or of an intra-abdominal testicle may also produce severe pain and distention. Unusual diseases that may produce symptoms similar to those of intestinal obstruction are lead colic, sprue, diabetes, tabes dorsalis, acute porphyria, and sickle cell anemia with abdominal pain.

F. DIFFERENTIATION OF SIMPLE AND STRANGULATING OBSTRUCTIONS

It is extremely important for the surgeon to decide as soon as possible whether a given obstruction is simple or strangulating in type. Obviously, if this differentiation could be made in a clear and definite fashion, many of the arguments concerning the proper therapeutic approach to intestinal obstruction could be resolved rapidly. While some surgeons believe they can classify these patients accurately, in the Massachusetts General Hospital the opposite point of view has been maintained. McKittrick and Sarris have emphasized the fact that in the individual case the differentiation cannot be made with any certainty, particularly within the first 24 hours, the golden hours of surgical therapy.

On paper it is easy to single out the patients with strangulating obstruction. A careful analysis by Reinus has shown that the important signs of strangulation are a history of steady pain with sudden onset, a seriously ill patient (even in the absence of peritoneal signs), abdominal tenderness, the presence of a mass palpable either by abdominal or by rectal examination, a temperature of over 101 F., and a pulse rate of over 110. The differentiation of the type of obstruction becomes easier the longer a patient is ill, since, at the end of 48 hours nearly all patients with strangulating obstruction will be seriously ill or even moribund.

However, analyses of clinical data do not indicate that any single symptom

TABLE 2.—DIFFERENTIAL FEATURES, SIMPLE AND STRANGULATING OBSTRUCTION

SIGN OR SYMPTOM	TYPE OF OBSTRUCTION					
	Simple			Strangulating		
	Becker	Reinus	Smith *et al.*	Becker	Reinus	Smith *et al.**
Appearance						
Seriously ill		17			75	
Shock		1			12	
Temperature						
Over 100 F.	15			23		
Over 101 F.		1			50	
Pulse rate						
Over 100	15		27	23		43
Over 110		1			75	
Tenderness	72	66	61	82	90	86
Rebound tenderness		17	23		25	45
Distention		80			40	
Palpable mass	5	10		10	25	
Peristalsis						
Borborygmus		32			25	
Visible peristalsis		22			12	
Increased or normal			84			54
Decreased or absent			16			46
White blood cell count						
Over 10,000	44		39	50		65
Over 15,000		25				
Polymorphonuclear leukocytes					50	
Over 80%			34			49

* Quoted by Wangensteen, *Intestinal Obstruction*, p. 142.
All figures indicate per cent of total cases studied.

or combination of symptoms or signs can be depended upon to differentiate simple from strangulating obstruction. This fact is shown clearly in Table 2, which is a composite of the data of three investigators. The reader will note, in particular, the high frequency of tenderness in both types of obstruction, the surprising frequency of normal or hyperactive peristalsis in patients with strangulation, and the fallibility of the white blood cell count as a means of differentiation. Prostration, shock, fever, and a high pulse rate become the important distinguishing features of strangulation.

Since a protracted period of deflation by intubation has been used by

many surgeons, the development of techniques of differentiation of simple and strangulation obstruction is of great importance. Perry, VonDrashek and Wangensteen have noted in the University of Minnesota Hospital that 75 per cent of strangulating obstructions were diagnosed and treated without delay. In the others, a diagnostic method that offers great promise is pneumoperitoneography. After the injection of 500 to 1,000 cc. of air, the strangulated segment was clearly demonstrated, though previous radiologic studies had been equivocal.

RELATIVE FREQUENCY OF STRANGULATION.—A clue to the presence or absence of strangulation is provided if the etiology of the obstruction is known. Some lesions regularly produce a strangulating obstruction; these include mesenteric thrombosis, external or intra-abdominal hernia, volvulus, intussusception, and certain congenital malformations. These lesions account for 10 per cent of the acute obstructions seen in the Massachusetts General Hospital.

Certain lesions may produce either a simple or a strangulating obstruction; they include adhesions, cancer of the colon, and surgical artefacts, such as hernias about anastomoses.

Finally, some lesions lead to simple obstruction, of which the commonest are paralytic ileus, megacolon, obturation obstruction, congenital malformations, inflammatory lesions, and compression of the intestine by tumor. Unfortunately, nearly all of the simple obstructions may lead to perforation, either by extension of the process itself (as direct perforation of a cancer of the colon) or by distention of proximal gut that results in perforation due to obliteration of blood supply (as perforation of the cecum in the presence of a closed loop obstruction of the colon). Therefore it is not correct to assume that so-called simple obstructions are free of the danger of perforation and peritonitis. Particularly in the presence of acute obstruction due to cancer of the colon, the surgeon may have a very brief period in which he may act before disaster occurs.

The over-all incidence of strangulation has been somewhat variable according to available reports. In round figures, it may be estimated that, exclusive of paralytic ileus, approximately 85 per cent of all obstructing lesions of the colon either may progress to early perforation or are strangulating in type.

In the present series, again exclusive of paralytic ileus, 15 per cent of the small-intestinal obstructions were strangulating. Corresponding figures of other authors include an incidence of 33 per cent of strangulation in 136 cases of small-bowel obstruction studied by McKittrick and Sarris; 26 per cent in 166 cases reported by Schlicke, Bargen, and Dixon; 27 per cent in 204 cases observed by Calihan, Kennedy, and Blain, and 43 per cent in 154 cases reported by Drugas and Schiff.

4

Types and Causes of Obstruction

INTESTINAL OBSTRUCTION MAY BE either acute or chronic. Unless otherwise specified, the disease is by common usage presumed to be acute. Two important causes of the acute and chronic type may be distinguished. Both may result from a mechanical block of the lumen, *i.e.* mechanical obstruction, or from functional changes on a neurogenic or vascular basis that prevent normal peristaltic action through an anatomically patent canal.

The term "ileus" is a synonym for intestinal obstruction and as such refers to both of these main types. Commonly, however, "ileus" is employed loosely to refer only to paralytic ileus. This usage is not correct, and the type of ileus should be designated whenever the word is used.

Mechanical obstruction, whatever may be the underlying cause, must be subdivided, both on clinical and on pathologic grounds, into two kinds. These are simple mechanical obstruction, in which there is no occlusion of the blood supply of the involved bowel, and strangulating obstruction, in which there is partial or complete occlusion of the mesenteric arteries or veins supplying the segment. To state that an obstruction is strangulating does not mean that gangrene is necessarily present but does imply that it will occur unless the obstruction is relieved. The presence or absence of strangulation can be determined only on direct examination of the involved gut.

Although these definitions can be stated clearly on paper, in practice it is found that the various kinds of obstruction are often difficult to distinguish, that there are some specific forms of obstruction which are difficult to classify rigidly, and that some types may progress from one to another with the passage of time. Thus, a paralytic ileus may be transformed into mechanical obstruction and simple mechanical obstruction into strangulating.

The surgeon, therefore, should attempt to decide at the outset, whether the obstruction is simple or strangulating. Thereafter, attention should be turned to two other problems. The first of these is determination of the level of the

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h. Balloons of intestinal tubes

3. Volvulus
   a. Primary (stomach, small intestine, cecum, transverse colon, sigmoid)
   b. Secondary
      (1) Associated with congenital abnormality
      (2) Secondary to surgical artefact
      (3) Secondary to bands, adhesions, stenosis, or obturation
4. Extraintestinal or extracolonic lesions
   a. Adhesions and bands
   b. Hernia
      (1) Extra-abdominal (inguinal, femoral, umbilical, epigastric, ventral, diaphragmatic, interstitial, prevesical, lumbar, obturator, sciatic, perineal, Richters, Littre's)
      (2) Intra-abdominal (paraduodenal, through foramen of Winslow, paracecal, intersigmoid, through omental or mesenteric defect, through broad ligament)
   c. Compression by extraintestinal mass
      (1) Carcinomatosis
      (2) Intraperitoneal abscess
      (3) Adjacent tumor (pelvic mass, renal cell cancer, echinococcus cyst, etc.)
      (4) Pregnancy
      (5) Foreign body
      (6) Of duodenum, by superior mesenteric vessels
      (7) Of duodenum, by annular pancreas
      (8) Wandering spleen
5. Obstruction secondary to surgical operation (other than that due to adhesions)
   a. Wound dehiscence
   b. Intraperitoneal abscess
   c. Anastomotic obstruction (edema or stricture)
   d. Anastomotic leak
   e. Obstruction of external stoma
   f. Hernia through trap or peritoneal defect
   g. Volvulus about fixed point

II. Acute obstruction with open lumen
   1. Megacolon
      a. Congenital aganglionosis (Hirschsprung's disease)
      b. Acquired megacolon
   2. Paralytic ileus
   3. Spastic ileus
   4. Mesenteric thrombosis and embolism

B. *Chronic intestinal obstruction*

RELATIVE FREQUENCY OF TYPES OF OBSTRUCTION

Data concerning the relative frequency of the various types of obstruction and the etiologic agents demonstrate historical trends, provide a rough guide for clinical use, and give information that aids in the interpretation of mortality statistics.

obstruction. In general terms, the site of block should be localized in the colon or small intestine and an attempt made to determine the anatomic segment involved.

Finally, the exact etiology should be considered. While this often cannot be determined before laparotomy, the surgeon should, as a matter of training and sharpening his diagnostic acumen, specify the suspected cause in his preoperative diagnosis.

From the point of view of etiology, Table 3 includes the common causes of obstruction, which will be discussed in detail in later chapters.

TABLE 3.—CAUSES OF OBSTRUCTION

A. *Acute Obstruction*
- I. Due to mechanical occlusion of lumen
  - 1. Intrinsic lesions of intestine or colon
    - a. Congenital defects
      - (1) Atresia and stenosis
      - (2) Malformations of anus and rectum
      - (3) Errors in rotation of intestine
      - (4) Duplications and cysts
      - (5) Meckel's diverticulum
    - b. Inflammatory lesions
      - (1) Of small intestine (regional enteritis, tuberculosis, diverticulitis)
      - (2) Of colon
        - (a) Diverticulitis
        - (b) Lymphogranuloma and other causes of rectal stricture
        - (c) Ulcerative colitis and regional colitis
        - (d) Other inflammatory lesions (tuberculosis, actinomycosis, bacillary dysentery)
      - (3) Eosinophilic granuloma
    - c. Tumors
      - (1) Cancer of colon
      - (2) Sarcoma (lymphosarcoma, fibrosarcoma, leiomyosarcoma, angiosarcoma)
      - (3) Benign tumors (fibroma, leiomyoma, adenoma, lipoma, angioma)
      - (4) Carcinoid
    - d. Traumatic lesions
      - (1) Traumatic strictures
      - (2) Hematoma
    - e. Intussusception
    - f. Radiation strictures
    - g. Endometriosis
    - h. Pneumatosis intestinalis
  - 2. Obturation obstructions
    - a. Gallstones
    - b. Bezoars and food boli
    - c. Foreign bodies
    - d. Enteroliths
    - e. Fecal impactions
    - f. Worms (ascariasis, tape-worm)
    - g. Meconium

were due to adhesions, 13.7 per cent to carcinomatosis, 6.8 per cent to external hernia, and the remainder to a variety of causes.

The incidence of strangulating obstruction has already been considered, in Chapter 3.

The relative frequency of the different types varies with age, so that the surgeon has a further guide to the probable diagnosis in the age of the patient. The causes of obstruction in the neonatal period will be listed in Chapter 10. In children, strangulated hernia, intussusception, and volvulus account for most obstructions of the intestine and congenital megacolon for most in the colon. Obstruction in young adults rarely occurs from lesions of the colon; in the intestine, strangulated hernia, adhesions, and Meckel's diverticulum are commonest. In older groups colonic obstruction becomes important, being due to cancer, diverticulitis, or volvulus, while small-intestinal obstruction usually is due to postoperative adhesions, carcinomatosis, strangulated hernia, or obturation.

Changing trends in the incidence of the various types of obstruction are shown in Table 4, which summarizes two representative series from the Massachusetts General Hospital. The first, reported by McIver, consists of 335 cases observed in the 10-year period 1920-1929. The second includes 1,035 consecutive cases seen in the eight-year period 1947-1955.

The most striking feature is the reduction in frequency of strangulated external hernia. This reduction obviously is due to the fact that hernias are repaired much earlier now than they were in the past. On the other hand, cancer, either primary or disseminated as carcinomatosis, has become a much commoner cause of obstruction. Bands and adhesions comprise approximately one-third of the cases in both series. Several new diseases have made their appearance as a cause of obstruction, including diverticulitis, regional enteritis, and radiation stricture. In comparison with these groups, all other causes of obstruction are rare and show no significant trend in the two series.

TABLE 4.—INCIDENCE, TYPES OF OBSTRUCTION

CAUSE	M.G.H. 1920-1929 McIVER	M.G.H. 1947-1955
Strangulated external hernia	44%	5.4%
Bands and adhesions	30	39.2
Neoplasms		
Primary cancer of colon	10	20.8
Carcinomatosis	—	10.3
Intussusception	5	2.1
Volvulus	4	1.6
Mesenteric thrombosis	3	0.9
Gallstones or other cause of obturation	2	0.8
Internal hernia	1	0.6
Meckel's diverticulum	0.6	1.2
Other congenital anomalies	0.6	0.9
Operative complications (except adhesions)	—	4.6
Diverticulitis		4.3
Regional ileitis		1.6
Radiation stricture		0.7
Other causes	—	5

The relative frequency of each type of obstruction gives a rough guide to the probable diagnosis. Thus, in the recent series, obstruction of the colon was encountered in 26.6 per cent of all cases; in the remainder the small intestine was involved. In a few cases, particularly when the underlying disease was carcinomatosis, the large and the small intestine were involved by separate obstructions. Large-bowel obstruction was due to cancer in approximately 80 per cent of the cases, to diverticulitis in 16 per cent, and to other causes in the remainder. Of the small-bowel obstructions, 52 per cent

In the normal adult about 8,200 cc. of fluid is secreted by the gastrointestinal tract daily. This includes 1,500 cc. of saliva, 2,500 cc. of gastric juice, 500 cc. of bile, 700 cc. of pancreatic juice, and 3,000 cc. of intestinal juice. While the electrolyte loss will be discussed in more detail later, it may be noted here that, though this includes only a small amount of potassium, it comprises about 55 Gm. of sodium chloride, which is nearly twice the weight of the total plasma salt. Normally little absorption of water or salts occurs in the jejunum, so that a high obstruction results in a rapid loss of water and electrolytes. On the other hand, since normal absorption occurs in the ileum and right colon, very little dehydration accompanies left colic obstruction. There is, also, some evidence that the amount of secreted digestive fluids is increased by intestinal obstruction; fluid and electrolyte losses, therefore, may be even greater than indicated by the above figures.

The chemical nature of the gases that accumulate in the obstructed loop is of great interest. Normally large amounts of carbon dioxide are produced by digestive processes. Carbon dioxide, oxygen and hydrogen sulfide readily permeate the mucosal barrier, as shown by McIver, Benedict, and Cline (1926). They found that nitrogen, methane, and hydrogen were absorbed poorly.

Quantitative analyses by Hibbard and Wangensteen of intestinal gas in experimental obstruction in dogs showed nitrogen 70 per cent; oxygen 10 to 12 per cent; carbon dioxide 6 to 9 per cent; hydrogen sulfide 10 per cent; hydrogen and methane each less than 1 per cent. These studies suggested that the source of the gas that appears above a point of obstruction is chiefly, if not entirely, swallowed air. The studies by Hibbard and Wangensteen, in 1934, indicated that 68 per cent of the gas was due to swallowed air, about 20 per cent to diffusion of blood gases into the bowel lumen, and 10 per cent to putrefaction within the distended loop. In a later series of experiments with dogs, Wangensteen and Rea eliminated the possibility of swallowing air by division of the cervical esophagus. Subsequently, obstruction of the lower ileum was produced. After an average survival period of 35 days, autopsy showed slight or no distention of the obstructed gut in 9 of 11 dogs. Andersen and Ringsted, in 1943, concluded that swallowed air is the exclusive source of gas in all types of obstruction.

Meanwhile the increasing intraluminal pressure leads to important changes in the intestine itself and in the peritoneal cavity. The small intestine tends to dilate. High intraluminal pressures do not result unless there is a closed loop obstruction, because the tract is decompressed by vomiting. Pressures rise to a much higher level in the obstructed colon, particularly when the ileocecal valve is competent and a closed loop type of obstruction is present. Wangensteen found a sustained pressure varying between 4 and

5

Theoretical Considerations

A. PATHOLOGY AND PATHOLOGIC PHYSIOLOGY OF INTESTINAL OBSTRUCTION

MECHANICAL OBSTRUCTION PRODUCES different effects according to the site of obstruction, rate of obstruction, presence or absence of strangulation, length of a strangulated loop, and specific type of obstruction. The pathologic sequences noted in acute mechanical obstruction will be considered first.

The primary response to obstruction consists of a marked increase in peristaltic activity, particularly in the segment just proximal to the obstruction. This may produce a normal bowel movement, which is often noted at the outset, and account for the frequent small movements that occur with partial obstruction.

Edema of the bowel wall occurs promptly at the site of obstruction and may make a partial occlusion complete within a short period. The importance of this factor is shown clinically by the fact that many obstructions subside spontaneously after decompression by an enterostomy tube or by an intestinal tube.

Distention then occurs proximal to the obstruction, while the distal bowel collapses. The distention is due to a collection of swallowed air and digestive products combined with a decreased absorptive power. Meanwhile the amount of fluid secreted into the digestive tract actually is increased in amount.

The sources of fluid and gas in an obstructed intestine include swallowed air, liquid or food, normal digestive secretions, and gas formed by intestinal putrefaction. The relative importance of these factors is variable, but the researches of Wangensteen and others have shown that major significance must be attached to swallowed air and to lack of absorption of normal digestive fluids.

small intestine large ulcers occasionally are seen, and in a few instances the obstruction is followed by a typical acute pseudomembranous enterocolitis.

The distention reduces peristalic activity. Large atonic loops of intestine then kink, and these angulations produce multiple points of obstruction. Unless the obstruction is high, a significant or extreme degree of abdominal distention is produced; as a result the diaphragm becomes elevated and pulmonary congestion results. Venous pressure is increased in the lower extremities as well as in the bowel wall, and circulation time is slowed. All of these factors contribute to venous stasis, thrombosis, and embolism, one of the commonest complications of obstruction.

Body fluids meanwhile become depleted. Blood loss has already been mentioned. The effective blood volume falls significantly because of distention of the mesenteric vessels. The plasma loss is high, since the edema fluid contains a great amount. Water and electrolyte loss is also great. Gendel and Fine found in the experimental animal that 28 per cent of the blood volume and 48 per cent of the plasma volume could be lost within four hours of the onset of strangulating obstruction.

Microscopic examination of obstructed bowel reveals only edema of the intestinal wall, capillary stasis, and flattening of the villi in simple obstruction. With the onset of strangulation, thromboses appear in the compressed intramural vessels, to be followed by necrosis of mucosa, dissolution of the muscular coats, perforation, and peritonitis.

The changes described above are characteristic of mechanical obstruction. In other types the intestinal lumen remains patent but activity is prevented by other causes. In paralytic ileus the bowel is anatomically normal but normal peristalsis does not occur, presumably because of inadequate nervous or chemical stimulation. Later in the course of the disease distention may reduce the blood supply and by angulation of huge coils produce an actual mechanical obstruction. In patients with congenital megacolon, normal peristalsis cannot occur in the abnormal segment in the distal colon or rectum because of an absence of ganglionic cells. In mesenteric thrombosis or embolism, peristalsis disappears because of lack of blood supply.

B. TOXIC ABSORPTION

The absorption of some noxious material from the obstructed intestine for many years has been assumed to cause many of the symptoms of intestinal obstruction and to be an important factor in the mortality of this disease.

Clinical observations have been cited as evidence in favor of this hy-

14 cm. of water in the obstructed small intestine of man; this compared with a sustained pressure of between 12 and 52 cm. of water in acute obstruction of the colon. These pressures are far below those produced by an ordinary enema (90 cm. of water if a 3-foot gravity flow is used) and that which is required to perforate the colon (about 250 cm. of water.) Rack found that perforation of the cecum occurred in 1.5 per cent of 509 patients with cancer of the colon. It is due chiefly to the diminution in blood supply from the distention. The vessels must stretch to correspond to the increased circumference of the bowel, or over three times as rapidly as the diameter increases ($C = \pi D$).

Moreover, *in the colon the greatest tension is exerted in the cecum,* because it has the largest diameter. According to McAdams, since tension per square centimeter of surface = diameter of bowel, $\times \pi \times$ intraluminal pressure, cecal pressure may be four times as great as in the left side just above an obstructing cancer.

Distention increases the diameter of the bowel, shortens it in length, and *thins the wall.* The edema present increases its weight and then makes it resemble a piece of wet blotting paper. The intramural blood vessels likewise are stretched, and capillary anastomoses are obliterated. Blood flow is reduced, and stasis occurs, first in the venous and then in the arterial system. Actual obliteration of mesenteric arterioles or venules requires pressure in excess of those observed clinically. Sustained lower pressures, however, have been shown by Sperling and Wangensteen to produce such an effect. In dogs a pressure of 10 cm. sustained for 28 hours led to petechial hemorrhages and of 20 cm. to necrotic, nonviable bowel. Finally, hemorrhage into the bowel or mesentery results, and, as the blood supply to the bowel disappears, gangrene develops, to be followed by perforation, peritonitis, and death.

With strangulation, profuse bleeding sometimes occurs, either into the lumen of the bowel, into the mesentery, or into the peritoneal cavity. This may be severe enough to produce hemorrhagic shock. It is due to primary occlusion of the venous supply by the obstructing mechanism: arterial blood continues to circulate under pressure in the involved loop and must seek some abnormal outlet.

Not infrequently superficial mucosal ulcers form proximal to the site of obstruction. They have been observed more commonly extending from a partially obstructing cancer of the colon back to the ileocecal valve and closely resemble an idiopathic ulcerative colitis. They apparently have become commoner recently, and this fact has led to the speculation that preparation of the bowel for operation with phthalylsulfathiazole (Sulfathalidine) or succinylsulfathiazole (Sulfasuxidine) may play a role. In the

as it is present in the peritoneal exudate, this exudate becomes fatal on injection into the experimental animal.

If it is accepted that the wall of strangulated bowel is permeable to certain toxic materials, it should be possible to determine more accurately when the wall of the bowel in late simple obstruction loses its protective power. Whether this loss occurs with disintegration of the mucosal barrier or at a deeper level is not certain. It is of interest that severe toxic manifestations accompany the disease of acute pseudomembranous enterocolitis, in which ulcerations are superficial, involving the mucosa, and bacteria multiply on the surface. By analogy it seems likely that an intact mucosa is the most important factor in the prevention of toxic absorption due to intestinal obstruction. While further research should tend to clarify this important problem, most investigators now believe that the mucosa itself is the barrier that prevents abnormal absorption.

C. BACTERIOLOGY AND ANTIBIOTICS

The importance of bacteria as a cause of many of the manifestations of intestinal obstruction has been considered for many years but has assumed even greater significance because of recent investigations. Normally the intestine contains a variety of aerobic and anaerobic organisms, of which the most significant are Bacillus coli, Streptococcus fecalis, Staphylococcus albus, and Cl. welchii. Nemir, Hawthorne, Cohn, and Drabkin found that only Cl. welchii, B. coli, and Str. faecalis could be recovered from the peritoneal fluid in the presence of strangulating obstruction. That the bowel is permeable under certain circumstances to bacteria has been proved by Fine, who observed migration of B. coli, tagged radioactively, through the bowel walls in dogs who had had peritonitis produced by a chemical irritant.

Cl. welchii has been identified by many observers as a source of lethal substances encountered in intestinal obstruction. Williams first stressed its importance in 1926. Since that time many other observations have led to the same conclusion. The great quantitative increase of Cl. welchii in the intestine of dogs in strangulating obstruction was proved by several investigators, including Hobbs and Kennedy, who found Cl. welchii in 17 per cent of cultures of the unobstructed intestine, as compared with 95 per cent after obstruction had been established. Anderson and Tanturi identified lecithinase, the alpha toxin of Cl. welchii, in the bowel lumen five hours after onset of experimental strangulation and found that it was present in 11 out of 12 animals that survived five to 24 hours after the strangulation. Laufman, Tanturi, and Furr found lecithinase in thoracic duct lymphs of dogs dying of strangulating obstruction.

Cohn, Nemir, and Hawthorne carried out a highly significant series of

pothesis. In patients with advanced obstruction, either simple or strangulating, there developed prostration, clouded psyche, a high temperature, a low blood pressure, and an elevated pulse rate—symptoms conveniently explained by "toxic absorption."

Occasionally after relief of a late simple obstruction, when contents of the obstructed intestine have been allowed to remain in the distended intestine or to flow into normal distal bowel, a fulminant rise in temperature and death have occurred; this has suggested that some fatal substance had been elaborated in the intestine and absorbed after relief of the obstruction.

Insofar as simple obstruction is concerned, the importance of toxic absorption has not been confirmed by experimental data. Toxins have indeed been recovered from the contents of obstructed loops (histamine, proteoses, etc.), but they have been recovered from the normal intestinal contents as well. It is known that there is a significant overgrowth of Clostridium welchii in the contents of obstructive loops and that extracts made from the mucosa of obstructed loops in dogs produce profound collapse when injected intravenously into normal dogs. Furthermore, according to Davis and Stone, these mucosal preparations lose their toxicity after elimination of bacteria. Such experiments suggest a bacterial source of a toxin.

To prove the validity of the theory of toxic absorption it is necessary to prove that the obstructed bowel wall is permeable to some substance that the normal wall is not. However, with simple obstruction and an intact intestinal mucosa, the evidence shows that absorption of some substances, such as water, salts and dextrose solution, is reduced in the obstructed bowel, while another substance, the vital dye trypan blue, is not absorbed by the normal but is absorbed from an obstructed bowel.

On the other hand, most of the clinical features of "toxemia" may be produced by distention itself and by water and electrolyte deficits. Experimental hypopotassemia in the human volunteer, for example, produces prostration, a rising temperature, and intestinal distention because of a severe paralytic ileus.

For these reasons the role of toxins in early simple obstruction is now generally regarded as unimportant. The situation is far different when the mucosa is damaged in strangulating obstruction or in the presence of ulceration due to bacterial or vascular damage. There is increasing proof that in this case substances of some type escape from the intestine. There is not complete agreement concerning their nature or origin, although Cl. welchii is believed by many investigators to be the source of the toxin. A second possible source is a breakdown product of hemoglobin which has been identified in the obstructed strangulated bowel by Nemir, Hawthorne, Cohn, and Drabkin in dogs; this later penetrates the intestinal wall and, as soon

wall in the presence of obstruction. This theory was propounded by Stone, Bernheim, and Whipple in 1912. They then believed that proteoses were formed by the disintegration of mucosa and that proteose intoxication accounted for the toxic symptoms of intestinal obstruction. However, Stone from later investigations, concluded that sterile mucosal extracts were nontoxic but became toxic when incubated with their own bacteria.

D. CAUSES OF DEATH

The physiologic abnormalities which lead to death from intestinal obstruction may be summarized briefly as follows.

1. Distention.—This is not lethal in itself, but it leads to impaired absorption of water and electrolytes, fluid and electrolyte depletion, increased permeability of the bowel wall to bacteria and certain other substances, venous stasis, and thromboembolism.

2. Depletion of Water, Electrolyte, and Blood Reserves.—Death may result from dehydration or serious electrolyte imbalance alone, particularly when the obstruction is high. Loss of plasma is important in all types of obstruction. With strangulating obstruction, death may occur from oligemic shock following hemorrhage.

3. Peritonitis.—One end result of strangulating obstruction or of perforation superimposed on simple obstruction is peritonitis. It can be overwhelming in its severity and may be fatal even when treated promptly.

4. Toxic Absorption.—This factor has not been proved to be important in simple obstruction when the mucosa is intact. When strangulating obstruction exists, there is evidence in its favor. The nature of the toxins has not yet been determined, though probably they are those elaborated by Cl. welchii.

5. Inanition.—A cause of death in intestinal obstruction that deserves emphasis is inanition. Most causes of obstruction are relieved promptly enough by one means or another, so that this factor never need be considered. On the other hand, complete simple obstruction may now persist for a period of days or weeks and the patient be kept alive by adequate decompression and intravenous alimentation. Under such circumstances, unless the obstruction is relieved the patient ultimately dies of inanition. This factor is particularly important in cases in which there are combined intestinal obstruction and peritonitis.

Experimental observations of this cause of death were made by Schilling, McCoord, and Clausen. They produced simple obstruction of the terminal ileum in dogs. When there was no oral intake, there was little distention and practically no vomiting. One animal, for example, lived comfortably and

experiments. They isolated an intestinal loop, dividing its blood and lymphatic supply as well, and re-established intestinal continuity. If the loop of bowel was closed and left intraperitoneally, death occurred. If the bowel was autoclaved and returned to the peritoneal cavity, the dog survived. When the loop was sterilized and returned to the peritoneal cavity, together with sublethal doses of Cl. welchii, death occurred. They concluded that death in strangulation obstruction was due to exotoxins of Cl. welchii produced in the presence of dead tissue and that the presence of dead tissue was necessary to allow sublethal doses of Cl. welchii to kill the animal.

Whether or not death is due to this specific organism and its products, there is no question but that antibiotics have reduced the mortality of obstruction in the experimental animal, proving the importance of bacteria in causing death. Harper and Blain placed penicillin in isolated closed loops; this measure protected animals from the usual toxic manifestations and prolonged life. Phthalylsulfathiazole (Sulfasuxidine) was found to be protective by Sarnoff and Poth and streptomycin by Davis, Gaster, Marsh, and Pritel. Cohn found that the postoperative administration of tetracycline (Achromycin) by catheter in an obstructed loop in dogs results in a nearly normal appearance of the mucosa and survival of the animals, in sharp contrast to the destroyed mucosa that is noted when antibiotics are not given. Rabinavici and Fine demonstrated conclusively that bacterial action is a major factor in the conversion of a sublethal to a lethal degree of vascular injury of the dog's gut; they used chlortetracycline (Aureomycin) in their experiments. It thus appears in experimental obstruction that with proper antibiotic protection, strangulated obstructed loops of bowel can be kept viable for an indefinite period.

A second type of toxin, alluded to above, has been investigated by Nemir, Hawthorne, Cohn, and Drabkin. They analyzed the pink peritoneal fluid that accompanies early experimental strangulating obstruction and compared it with the reddish-black fluid of late strangulation. The pink fluid is nontoxic, but the black is fatal when injected into dogs. The important toxic substance appears to be a derivative of hemin. It is found first in the obstructed bowel contents, then in the peritoneal cavity, and finally in the blood stream. The same substance has been identified in man, though its importance has not yet been established.

While absorption of these toxic substances theoretically might progress either through the lymphatics, through the venous blood supply, or by way of the peritoneum, in the presence of strangulating obstruction the transperitoneal absorption apparently is the important one.

Another source of toxins could be furnished by autolysis of the intestinal

6

Immediate Treatment and Selection of Time for Operation

SUCCESSFUL TREATMENT OF acute mechanical intestinal obstruction depends upon a judicious combination of several procedures. They include operation: specific mechanical methods of relief for certain types of obstruction; decompression of the intestine by intubation; replacement of water, electrolytes, plasma, and blood, and administration of antibiotics. These features will be considered in order, but first a general outline of the management of a typical case of obstruction will be presented.

A. IMMEDIATE TREATMENT

When a patient is admitted to the hospital with a possible diagnosis of intestinal obstruction, the attending surgeon must realize that he is dealing with a problem of extreme urgency. Viable bowel deprived of its blood supply rapidly develops gangrene, and a few hours may make the difference between success and failure. Essentially, obstruction is due to a mechanical cause and requires mechanical correction by surgery. In general terms, the shorter the period of obstruction, the greater the surgical emergency; conversely, if obstruction has existed for some time, adjuvant measures take precedence over operation. In his desire to consider all details of treatment, the surgeon must never forget this underlying principle, or valuable time will be frittered away.

As soon as a patient is admitted, diagnosis and adjuvant treatment must proceed smoothly and rapidly, culminating in surgery as soon as it judiciously can be done. During his examination the surgeon must have several ques-

actively for 37 days. The dogs exhibited only the phenomena of starvation before death or sacrifice.

COMMENT.—The causes of death as determined by autopsy will not necessarily be selected by the pathologist from this list but will be the anatomic result of these factors. The anatomic causes of death will be considered in detail in Chapter 29.

Summarizing the factors that produce death, Wangensteen concluded that "the chief lethal factor in simple obstruction is permeation of a gut wall whose viability has become impaired by bacterial and other deadly agents. In strangulating obstruction, apart from the blood loss factor, this too is the chief cause of death." For a thorough review of experimental data, the student should refer particularly to Wangensteen's monograph and to Cohn's survey of strangulation obstruction.

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Fig. 22.—Late intestinal obstruction due to adhesions. Woman, 75, was admitted five days after sudden onset of abdominal cramps, vomiting, and obstipation. She had had hysterectomy 30 years before. On entry she was thin and moderately dehydrated. Abdomen was moderately distended, with tenderness in left lower quadrant. Peristalsis was present and not high-pitched. Blood pressure was 180 90, pulse 116, temperature normal, and white cell count 11,100. Nonprotein nitrogen was 105 mg., sodium 137 mEq., potassium 4mEq., chloride 100 mEq., and carbon dioxide 27 mEq. Only a small amount of urine was obtained by catheter. During next 18 hours patient was treated by suction and intravenous fluids. Harris tube was inserted; it did not leave stomach and made little change in distention. Patient was given 2,000 cc. of 5 per cent dextrose in salt solution and 700 cc. of 5 per cent dextrose in water. Twelve hours after entry she began to excrete urine at rate of 25 cc. per hour. Eighteen hours after entry her pulse rate had fallen to 100 and nonprotein nitrogen to 75 mg. Operation was done at that time with lysis of adhesions of distal ileum deep in pelvis. Ileum above was dusky but viable, and color improved rapidly after aspiration of 1,000 cc of fluid. Postoperative course was uneventful, and patient left hospital 11 days later.

tions continuously in mind. They are:

1). Does the patient actually have obstruction?
2). Is the obstruction simple or strangulating?
3). What is the probable location and cause of the obstruction?

As soon as the history and physical examination are complete, either a Levin or a long intestinal tube is passed, laboratory studies instituted, and intravenous fluids started. The patient is then sent to the X ray department en route to the operating room or to the ward. Usually all essential data may be gathered in this way within two hours, so that operation, when it is indicated, should be possible shortly after that time.

B. SELECTION OF TIME FOR OPERATION

Within the same two hours the surgeon's course should be clear. Immediate operation is the therapy of choice if the patient has any one of the following conditions: (1) strangulating obstruction, actual or suspected; (2) acute simple obstruction of the small intestine provided symptoms are less than 24 hours in duration; (3) acute obstruction of the colon.

Since many obstructions do not fall into these categories, one of the simplest and best practical guides in the choice of therapy for acute small-intestinal obstruction is provided by the length of delay from the onset of symptoms to operation and is based upon the premise that the differentiation of simple and strangulating obstruction is often difficult or impossible.

The problem is simplest when the patient enters the hospital less than 24 hours after the onset of symptoms. McKittrick pointed out in 1941 that in the Massachusetts General Hospital no patient had died after operation for acute mechanical small-bowel obstruction in a 30-year period if operation had been done within this 24-hour period. A more recent review by McKittrick and Wheelock indicates that early operation has been just as successful since that time. Such patients have not been ill long enough to have severe systemic symptoms of obstruction even in the presence of strangulation, and they can be operated on with little more preparation than the insertion of a Levin tube and complete evacuation of the stomach. This record is such that it seems unwise to delay operation in any of these patients. At the Massachusetts General Hospital we can see no reason for treatment by intubation in this group unless the diagnosis is not clear, the obstruction is partial, or there have been multiple operations because of adhesions; obviously in none of these exceptions should there be any suspicion of strangulation.

When small-intestinal obstruction has been present for three days or more, a period of decompression by the long intestinal tube and intravenous replacement of fluid, electrolytes, and plasma are indicated. By this time near-

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Surgical Treatment

A. ANESTHESIA

THE GREATEST HAZARD OF ANESTHESIA for intestinal obstruction is aspiration of gastric contents. The extraordinary frequency of this complication after laparotomy has been demonstrated by Culver, Makel, and Beecher. They found evidence of aspiration below the vocal cords in 16 of 300 patients studied by the instillation of Evans blue dye into the stomach before operation. Obviously, when the patient has intestinal obstruction opportunities for aspiration are even greater. Unless the stomach is empty and the stomach tube is kept on suction during induction, there may be sudden filling of the stomach and regurgitation as soon as the sphincter relaxes. As an additional safeguard, the insertion of a cuffed intratracheal tube before anesthesia is started is wise. General anesthesias are by far the most satisfactory. Thiopental (Pentothal) combined with one of the muscle relaxants will give the wide exposure that often is necessary. Spinal anesthesia gives good relaxation but often causes a precipitous drop of blood pressure in these very ill patients. Local anesthesia is good when a specified procedure can be done, as, for example, cecostomy or repair of a strangulated hernia.

B. INCISIONS

In some instances the surgeon has a definite diagnosis and can make a short incision for one specific purpose. Thus, a "blind" cecostomy or transverse colostomy may be done if the surgeon is sure that he is dealing with cancer or diverticulitis of the distal colon. Such a procedure is wise when there is enormous distention of the colon. Frequently, however, a diagnosis of obstruction is not definite or the cause of the obstruction is not certain; under these circumstances, the surgeon's first duty is to establish the diagnosis and the site and nature of the obstruction. This requires an adequate

ly all patients with strangulation are dead or moribund. Those with simple obstruction, on the other hand, are greatly depleted. If intubation is successful, a day or more may be spent in preparation. If the tube does not enter the upper small bowel within 6 to 12 hours and distention is not reduced significantly, operation is indicated at that time.

It is the group midway between these two extremes that is the most difficult to treat. Great variations in opinion will be encountered here. Since the incidence of strangulating obstruction is relatively high, the author prefers early operation, after several hours of replacement therapy. The stomach is emptied by a Levin tube to prevent aspiration under anesthesia. The obstructed intestine will be emptied by operative decompression of the intestine at the time of laparotomy.

While each patient presents an individual problem, the management of early representative patients may be followed by reference to Figures 7 and 8 and that of late cases by reference to Figure 22.

In a series of patients operated on by the author, the mean interval from hospital entry to operation was two and one half hours in those patients whose symptoms were of less than 24 hours' duration. The corresponding period of preparation in those with symptoms of 1 to 3 days was 18 hours; with symptoms of 3 to 7 days, 48 hours; and with obstruction of over a week's duration the mean interval was 3 days.

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formation may be encountered later. These are all serious complications and much more dangerous than those associated with resection and anastomosis.

D. ASPIRATION OF BOWEL

Aspiration of the intestine at the time of laparotomy has enjoyed periods of popularity and periods of disrepute. Before the era of gastric and intestinal tubes it was found to be the most effective way to reduce distention. Many famous surgeons, such as Moynihan and Monks, approved this method. The tubes they used were usually of large diameter, with multiple perforations; as the bowel collapsed on aspiration it was pleated over the tube.

Such an operation, of course, involved a certain amount of contamination and a great deal of manipulation of the intestine. Mortality rates were high, not so much because of the method as because of the advanced obstruction and lack of appreciation of proper replacement therapy. With the advent of effective decompression methods in 1932 aspiration of the bowel generally was abandoned. It was condemned by Ochsner and Storck in 1936 on experimental and clinical grounds, since manipulations of the distended bowel produced a significant fall in blood pressure.

Now that adequate replacement therapy has made these procedures relatively safe, the advantages of aspirating the bowel have become clear. They include facilitation of the operation, immediate relief of distention with return of normal circulation, and the removal of intestinal contents that are poorly tolerated by the patient.

1. Facilitation of operation.—In many patients with advanced distention, it is impossible to discover the exact site of obstruction until the bowel is aspirated. Eventration of huge loops is prevented. Wound closure, impossible before aspiration, becomes easy thereafter.

2. Relief of distention.—The intestine changes from a dark purple to normal color as arteriolar pulsations resume. The importance of the reduction of distention was shown by Noer, Derr, and Johnston, who found, in their studies of the vasa recta of the intestine, that the blood supply was reduced significantly by even small degrees of distention. Evidence of peristaltic activity returns. Furthermore, collapsed bowel can be replaced in the abdomen without the kinking that occurs so frequently when distended loops are forced back. The chances of postoperative obstruction are reduced.

3. Removal of intestinal contents.—The contents of a distended obstructed intestine with an intact blood supply, though often heavily contaminated with Cl. welchii, appear to be harmless provided the mucosa is intact. However, a number of investigations, cited above, have shown that

incision, which in general terms means a paramedian, either on the right or on the left. The exact location must be selected with care, since in many instances only a colostomy or cecostomy will be done and another laparotomy will be necessary a few days later.

C. CONDUCT OF OPERATION

The surgeon first notes the type of fluid in the peritoneal cavity. Bloody fluid nearly always means strangulating obstruction or pancreatitis. Clear, *straw-colored fluid indicates that no necrotic bowel is present.* Next, the *point of obstruction is identified. In early cases of small-bowel obstruction* this is easily done by locating the cecum or collapsed intestine in the right lower quadrant and following it back to the obstructing lesion, above which dilated bowel will be seen. If the cecum is distended the obstruction must be in the colon. Gentle palpation will identify obstructing bands or adhesions. Great circumspection is necessary in palpation of masses. The surgeon, for example, should not attempt to differentiate cancer from perforated diverticulitis of the sigmoid until he is prepared to resect the involved colon, and *it is unlikely that he will be so prepared at the time of the operation for acute obstruction. The intestine must be handled gently. Evisceration should be* avoided whenever possible. Strong pulls on the mesentery may lower the blood pressure perceptibly.

The great majority of obstructions must be treated by one of four methods. These are lysis of adhesions, resection of the obstructing lesion, creation of side-tracking anastomoses about the obstruction, and the formation of an artificial anus proximal to the obstruction. The technical details of these procedures will be discussed below. Specific methods are available for certain less *common types of obstruction, for example, enterostomy for obturation* obstruction.

When the surgeon has encountered a strangulating obstruction he must decide from the gross appearance of the intestine whether or not the intestine is viable. Before the obstructed mechanism is released the bowel may be black or a dirty purple, dull and lusterless, without any peristaltic activity when it is pinched lightly. After relief of the obstruction, the color of the bowel should return to near normal and peristalsis resume. If the intestine remains a deep purple or black, if thromboses are present in the mesentery, or if peristaltic action *fails to return after five to 10 minutes' observation,* the involved *intestine* should be resected. *When in doubt, resect.*

The fate of loops that are barely viable and are returned to the peritoneal cavity is of interest. Ulceration with perforation and peritonitis may occur after a few days. A fistula may occur, or, if healing does result, stricture

in the presence of strangulation, a lethal substance passes the mucosal barrier. This may be composed of enzymes released by the action of Cl. welchii, a breakdown product of hemoglobin as described by Cohn, or some other substance. At any rate, it is clear that the intestinal contents are of no value to the patient and may be very dangerous, and on this basis alone it is wise to aspirate the intestine at the time of laparotomy in all but the earliest cases of obstruction, provided the aspiration is carried out in an aseptic fashion.

It must be recognized that intestine may be distended by such solid material that any type of aspirating device will plug and fail to empty the bowel. In this case an enterostomy is necessary. Fortunately, in most early obstructions gas is mixed with thin fluid, so that removal is relatively easy. The easiest and most aseptic method of decompression is by means of a long intestinal tube previously introduced into the upper jejunum. At times, when the tube has not passed the pylorus, it can be manipulated through the stomach and into the upper jejunum. The Grafton Smith tube is effective for this purpose, since its rigidity aids passage. Unless one has experience with this method, manipulation of a tube through the pylorus may be difficult and traumatic or impossible.

By introducing his tube at the time of operation, Grafton Smith has reported successful decompression in over 50 patients in an average of less than 15 minutes, without any complications.

Alden has described an even simpler method that has been used successfully in 10 patients. A single lumen Koroseal tube 8 feet long with an outside diameter of 9/32 inch is prepared by cutting holes in the distal 10 inches. It is passed through the nose at the time of operation or before, and then manipulated through the stomach and into the intestine during laparotomy.

Usually when a tube is in the upper jejunum and the bag weighted with mercury, the tube will advance easily if the intestine is elevated repeatedly just behind the bag, gravity being allowed to pull the tube along, maintaining aspiration as it proceeds, as discussed by Nolan and Finlay.

When a tube is not in the proper position or will not advance, some other aspirator is necessary (Fig. 23). The author has used a simple one that can be arranged in a few moments with material present in every operating room (Fig. 24). A large bore needle (No. 15) is introduced at one or more points in the intestine, and with a little manipulation the bowel can be emptied easily. Intermittent release of pressure prevents aspiration of intestinal mucosa into the needle.

Many other mechanisms have been described. Williams and Williams have had success with an ordinary suction tip introduced through a pursestring suture. Cantor has used a stiff tube that can be extended by attaching

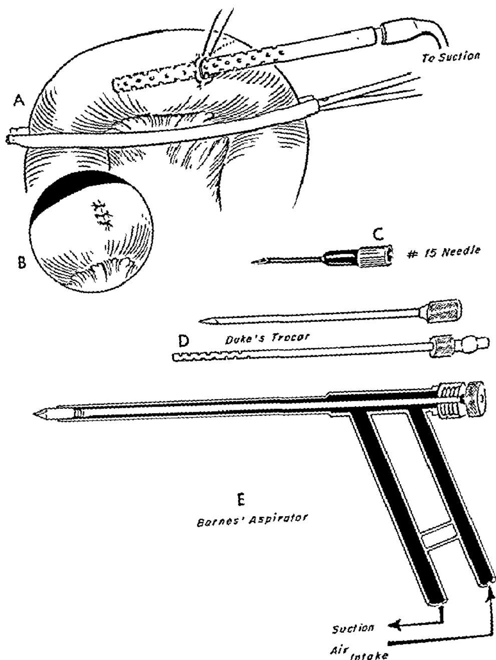


Fig. 23.—Means of decompressing intestine. **A**, suction trochar inserted through purse-string suture. Intestine has been emptied and rubber-covered clamp applied. **B**, closure of enterotomy in two layers. **C**, a No. 15 needle may be attached directly to suction. **D**, Duke's trochar provides a larger lumen than the No. 15 needle. **E**, Barnes' aspirator. By means of attached rubber tube, surgeon controls air intake by his foot.

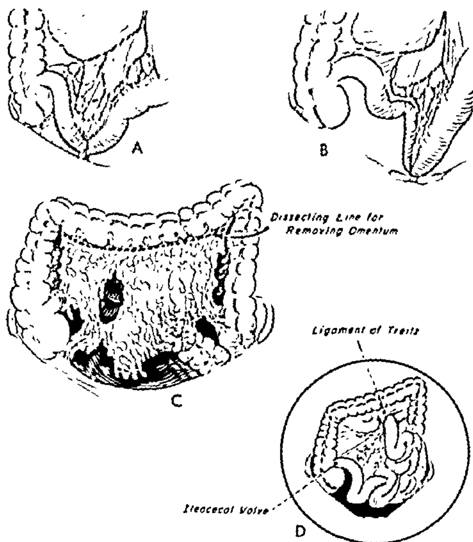


Fig. 25.—Lysis of adhesions. A, common cause of obstruction is congenital adhesions of distal ileum. B, single band is usual cause of obstruction after hysterectomy. C, omentum is common cause of obstruction, owing to dense adhesions, areas of scar or fat necrosis, or omental apertures. Omentectomy is best solution. D, at conclusion of operation, intestine has been mobilized from ileocecal valve to ligament of Treitz.

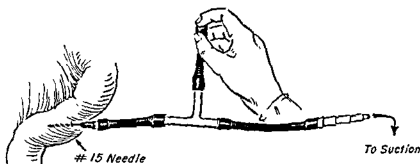


Fig. 24.—Simple method of aseptic decompression of intestine filled with gas or thin fluid. No. 15 needle is inserted into bowel. Intermittent elevation of assistant's finger on upper arm of T-tube releases suction and prevents aspiration of mucosa. If needle becomes plugged, suction can be cut off and system flushed out by syringe inserted in end of tube covered by finger, in illustration. After needle is withdrawn, small opening is closed by purse-string suture.

extra sections as required. Barnes has developed an aspirating trochar with a long air intake with which all of the manipulation can be carried out by the surgeon himself. Whatever method is used, it should involve a minimum of contamination and the least trauma to the intestinal wall consistent with complete evacuation. In some instances a resection is contemplated, and the enterotomy incision for decompression can be placed in a position where it will be included in the resected specimen.

E. WOUND CLOSURE

After the conclusion of the operative procedure, particular care should be taken with closure of the incision. Multiple retention sutures of wire or cotton are placed through the anterior rectus fascia 1 to 2 cm. lateral to the line of incision. Peritoneum is closed with catgut, fascia with interrupted non-absorbable sutures, preferably cotton, and skin with silk.

F. SPECIFIC OPERATIVE PROCEDURES

In general terms, the operative procedures designed to relieve intestinal obstruction fall into four categories: (1) Methods which do not require enterotomy, most commonly lysis of adhesions. Manipulative reduction of an intussusception and relief of a strangulated hernia by herniotomy are other examples. (2) Resection of an obstructing lesion and immediate restitution of intestinal continuity. (3) Entero-enterostomy about an obstructing lesion. (4) Establishment of a surgical vent or an artificial anus placed proximal to the obstruction.

There are, therefore, several standard operations for the relief of obstruction. Since they will be referred to frequently in the following pages, the

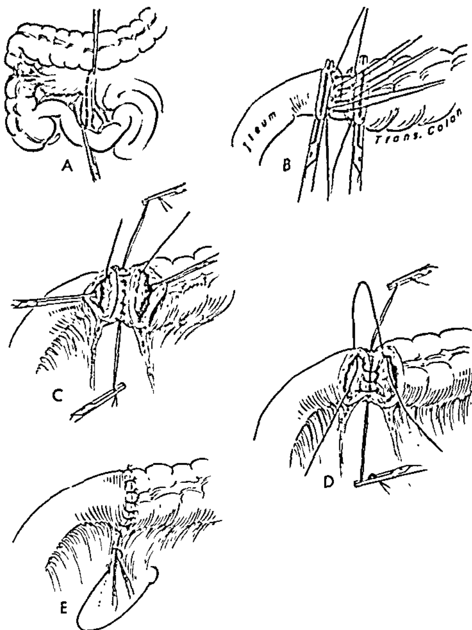


Fig. 26.—Reduction followed by end-to-end anastomosis; ileotransverse colostomy. **A,** application of clamps. Those on ileum are placed at oblique angle to increase diameter of anastomosed bowel. **B,** anastomosis is begun by outer layer of interrupted #30 cotton. **C,** clamps were removed as posterior outer row was tied. Posterior inner row of interrupted sutures of 000 catgut now is inserted. **D,** inner row is continued anteriorly. All but last few knots are placed within lumen. **E,** anastomosis is completed by anterior outer layer of cotton. Mesenteric rent is closed by running suture.

technical details of the common procedures will be described here, together with the complications that they may engender.

1. Lysis of adhesions (Fig. 25).—This operation, one of the commonest employed for obstruction, involves many considerations, and only the important technical details will be presented here. A fresh operative incision is desirable, since intestine may be glued to an old incision and be injured unless great care is used. In favorable cases only a few adhesions or a single band are encountered; the surgeon divides them and carefully observes the bowel to be sure there are no pressure points that might be devitalized and perforate later. Small areas can be infolded by a few Lembert sutures.

Usually, however, a mass of adherent omentum and intestine makes the operation arduous. By sharp dissection, the omentum and adherent bowel first are separated from the peritoneum. Later, deeper adhesions are exposed and divided. Obstruction from adhesions rarely involves the colon, but wide mobilization of the colon may be necessary before adherent omentum can be freed from intestine or pelvis. This traumatized omentum, which often is heavy and contains areas of fat necrosis, should be excised.

Some surgeons believe that in the presence of numerous adhesions, if a single one can be found that is producing obstruction, the others should be left alone. The writer believes, on the other hand, that the procedure has not been completed satisfactorily until all adhesions between the ligament of Treitz and the ileocecal valve have been divided. There are times, of course, when this goal cannot be attained and the procedure must be compromised because of the condition of the patient; recurrent obstruction at a later date is then not uncommon.

2. Resection and anastomosis.—Resection of the section of gut that includes the obstructive lesion, and primary anastomosis, is the operation of choice in many instances of obstruction. In the small intestine, partial enterectomy is most commonly used for strangulation obstruction or for localized obstructing adhesions from which the intestine cannot be liberated satisfactorily. After a resection, primary anastomosis is essential in the jejunum and mid or upper ileum. Low in the ileum or in the colon, a vent may be established safely either by ileostomy or by colostomy and intestinal continuity restored later. However, even in these areas, the cumbersome staged operations are becoming less popular, so that primary anastomosis now is done commonly except in the acutely obstructed left colon where distention is marked and cannot be relieved safely at the time of operation.

(*a*) technique.—The section of the bowel that is to be resected is isolated between two sets of clamps applied at an oblique angle to increase the diameter of the anastomosis and to maintain an adequate blood supply.

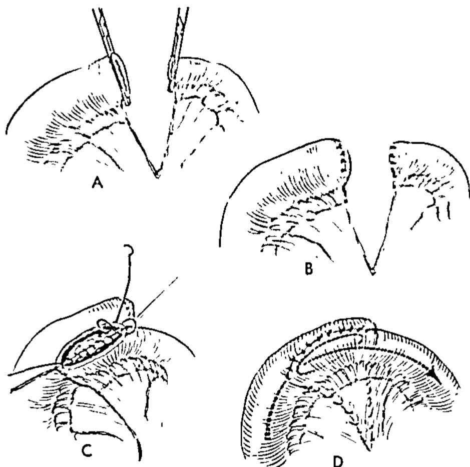


Fig. 27.—Resection followed by side-to-side anastomosis. A, intestine has been resected. B, ends are closed in two layers. C, mesenteries are overlapped, and anastomosis made by technique shown in Figure 30. D, final appearance of anastomosis. Arrow shows course of fecal current.

appears to be due entirely to technical causes. It is doubtful that this explains all malfunctions after anastomosis of stomach to duodenum or jejunum. Lack of tension, adequate blood supply, and a wide lumen are essential. If the anastomosis is a poor one, a leak or obstruction due to edema will occur. Months or years later contraction of an anastomosis may lead to an obstructing stricture.

(2) *Hernia*—Hernia behind an anastomosis may occur if the mesenteric loop has not been closed securely, and it may produce secondary obstruction early in the convalescence.

Vessels in the corresponding section of mesentery are divided and ligated. The bowel is then divided at each end, either with scalpel or with cautery. Anastomosis may be carried out by one of three techniques.

(1) *Open end-to-end anastomosis* (Fig. 26).—This, in the author's opinion, is by far the best method. Accurate placement of sutures and complete control of bleeding are achieved, and, with proper care, there should be no contamination from the open intestine. A posterior outer layer of interrupted Lembert sutures of cotton or silk is placed. Clamps are removed and the sutures tied. Then the posterior inner row of 000 chromic catgut is inserted. If the lumen is large the sutures may be continuous, but usually interrupted sutures are best, since they have less tendency to constrict the lumen. The anterior inner row is then placed, a Connell stitch being used if the lumen is wide and interrupted sutures if it is narrow. Then the outer anterior row, of interrupted cotton or silk sutures, is inserted. Patency of the anastomosis is assured by palpation. Finally, the mesenteric rent is closed.

(2) *Open end-to-side anastomosis*.—This is not a common type of anastomosis after resection. It may be used, for example, if there is extreme disparity in the diameters of the ileum and colon after a right colectomy, the surgeon closing the end of the colon and implanting the ileum just distal to this point. The technical details are similar to those shown in Figure 33.

(3) *Side-to-side anastomosis* (Fig. 27).—This anastomosis formerly was used commonly but now is unpopular because dilatation of the closed ends of bowel adjacent to the anastomosis may lead to late symptoms. It may, when the intestine is of tiny diameter, be the only possible method. Thus it may be necessary after resection for congenital atresia in infants.

(4) *Aseptic anastomosis*.—While numerous methods of aseptic anastomosis have been described, one of the simplest and best is that devised by Parker and Kerr. It is still employed by some surgeons when dealing with unprepared bowel. In the technique described here (Fig. 28), clamps are replaced by basting stitches, which are removed after a two-layer anastomosis has been completed.

(*b*) COMPLICATIONS.—Important complications of resection and anastomosis include (1) stomal malfunction due soon after operation to leakage or edema and later to stenosis; (2) hernia behind an anastomosis in which an open trap is left, for example, after side-to-side or end-to-side ileocolostomy; (3) formation of a blind pouch after a side-to-side anastomosis; (4) metabolic disturbances following massive resection; (5) reversal of an intestinal loop, a rare complication following multiple resections and anastomoses.

(1) *Stomal malfunction*.—In intestinal anastomosis, stomal malfunction

(3) *Formation of blind pouch after side-to-side anastomosis.*—One of the rare but important late complications of side-to-side anastomosis is dilatation of the blind proximal pouch of intestine. Black and McEachern have commented on the relative infrequency of symptoms arising from this cause and ascribe its rarity to the care with which such an anastomosis usually is made.

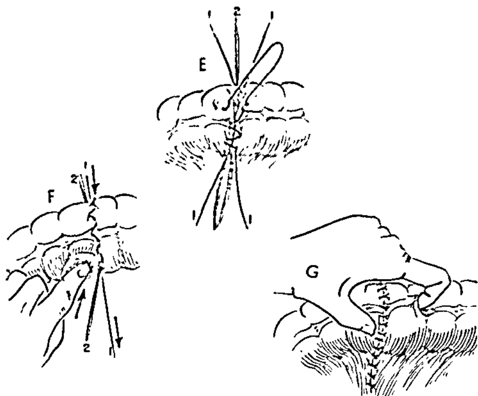


Fig. 28 (cont.).—E, completion of anterior inner row. F, basting sutures now are withdrawn. G, anterior outer row has been completed and V in mesentery closed. Thumb and index finger prove patency of anastomosis.

Pearce demonstrated in dogs that a blind loop of bowel distal to an anastomosis becomes functionless and diminishes in size if the direction of the peristalsis is away from the blind end and toward the anastomosis. This fact has been shown clinically in patients who have an ileocolostomy with exclusion of ileum distal to the anastomosis and in whom distention of the defunctioned bowel does not occur. However, Pearce also showed that if peristalsis is directed toward the blind end, the loops fill with feces; this situation leads to anorexia, lethargy, and death, either from perforation or from

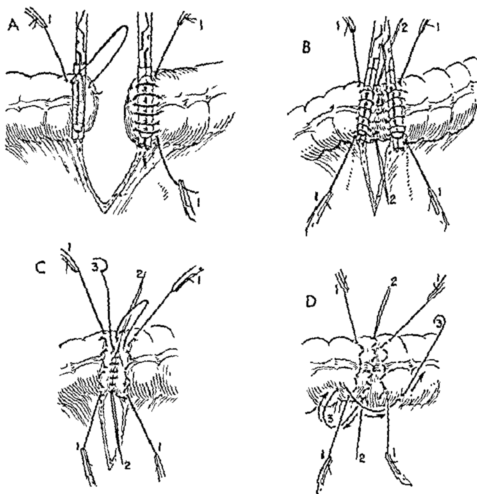


Fig. 28.—Parker-Kerr aseptic anastomosis. **A**, colon has been resected. Basting stitches (*1*) are applied close to each clamp. For purposes of orientation, it is well to place Kelly clamps at either end of one basting stitch and Kochers on others. Basting stitches of 00 chromic catgut should be lubricated before insertion to aid withdrawal. **B**, anastomosis is now begun. Outer row (*2*) is inserted on posterior aspect. Interrupted sutures are of cotton or silk. **C**, clamps are withdrawn and basting sutures tightened. Inner row (*3*) is running suture of 000 atraumatic catgut and must be placed close to basting sutures. **D**, inner row is brought around basting stitches to continue as anterior inner row (*continued*).



Fig. 29.—Massive resection of small intestine. Woman 43, had had three abdominal operations, including one for obstruction a week before. At that time, surgeon found severe obliterative peritonitis and had to close abdomen without definitive procedure. At fourth operation it was necessary to resect all but 3 feet of proximal jejunum and 1 foot of terminal ileum because of granulomatous peritonitis and multiple points of obstruction. This picture, taken three years later, shows entire length of small intestine. Barium is present in stomach and cecum. Patient was fairly active five years after extensive resection, though she was thin and had occasional episodes of diarrhea.

cipitated and excreted as calcium soaps in the stool, thus inducing severe hypocalcemia with tetany. Iron and vitamin absorption are impaired, and there may be serious electrolyte disturbances.

No satisfactory rule can be laid down that will determine whether or not these severe nutritional disturbances that occur nearly regularly after massive resection will be compensated at a later date. It is obvious that some persons in whom the small intestine is long can survive removal of 200 cm. of gut without symptoms, while others might lose nearly the entire length of the intestine if such a section were removed. The percentage of small intes-

cachexia. A length of over 2 feet was required in dogs to produce these changes.

In man symptoms occasionally are due solely to this dilated segment and can develop although the blind end of the proximal bowel is very short (Fig. 31). Colicky abdominal pain, distention, borborygmus, nausea and vomiting, diarrhea, nutritional disturbances, and anemia are the common symptoms according to Heifetz and Senturia. They have observed enough cases to believe that side-to-side anastomosis should be used only as a last resort. Clawson compiled the pertinent bibliography and believes there is overwhelming evidence that it is an unphysiologic procedure.

(4) *Metabolic disturbances following massive resection.*—Massive resections of the small intestine are defined by common usage as those resections in which over 200 cm. of the jejunum or ileum is removed. They are done most commonly for mesenteric thrombosis or volvulus. Abdominal injuries, regional enteritis, and strangulated internal hernia are other important causes. Multiple polyps led Camp and Lesser to excise the third and fourth portions of the duodenum, all of the jejunum, and a portion of the ileum. Stetten and Weinberger carried out successive massive resections for carcinomatous metastases. Extensive staged resections for sarcoid have been carried out by Wangensteen. The writer has resected all of the small intestine except 3 feet of upper jejunum in a patient with inextricable adhesions; microscopic sections showed fibers suggestive of cotton arising from a retained foreign body (Fig. 29).

Experimental studies by Clatworthy, Saleeby, and Lovingood, on 19 puppies who were subjected to resection of 40 to 80 per cent of the small intestine distal to the ligament of Treitz, indicated that this operation did not retard their growth or development. Compensation apparently depends upon an increase in the absorptive surface and a decrease in the motility of the remaining small intestine.

The surgeon dealing with intestinal obstruction nearly always has the extent of his resection dictated by the pathologic process present. Occasionally he has an option. In this respect, it is interesting to note that in dogs Kremen, Linner, and Nelson found that resection of the ileum was more likely to lead to nutritional disturbances than resection of the jejunum. The presence of the ileocecal valve also appeared to be of importance in maintenance of nutrition.

Massive resections are usually followed by a severe watery diarrhea with anorexia, nausea, and abdominal cramps. In man, it appears that absorption of fats is severely impaired and that of proteins is decreased moderately, while utilization of carbohydrates remains normal (Althausen, Kahn, and Simpson). When large amounts of fat are included in the diet they are pre-

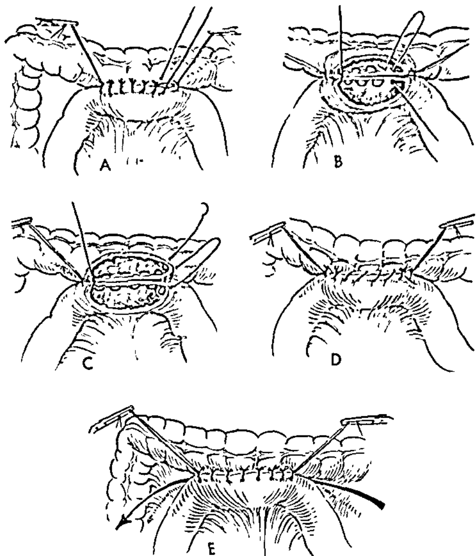


Fig. 30.—Side-to-side anastomosis; ileotransverse colostomy. **A,** ileum first is sutured to colon with interrupted cotton sutures. **B,** intestine has been opened. Posterior inner row (000 atraumatic catgut) is placed as Connell suture. **C,** detail, turning corner. Same suture is then continued back to complete anterior inner row. **D,** anterior inner row has been completed. **E,** outer anterior row of interrupted cotton sutures has been placed. There is large trap left behind such an anastomosis, providing chance for strangulation of loop of small intestine.

tine removed, therefore, is more important than the length. Haywood, in a study of 257 cases of massive resection, concluded that removal of 50 per cent of the small bowel constituted the upper limit of safety and that beyond this percentage poor results were the rule.

However, the literature contains numerous reports of the exceptional cases in which the patient has survived extensive resection. Bothe, Magee, and Driscoll, for example, reported a four-year follow-up of a massive resection of the small intestine from 15 cm. distal to the ligament of Treitz to within 6 cm. of the ileocecal valve. Richardson's patient survived 17 months after a similar resection before he died of cardiac failure; he had been having one bowel movement a day and had had no nutritional problems. Linder, Jackson, and Linder carried out a resection of all but 7 inches of the jejunum and ileum in a man of 31 years. He died three and one-half years later. Prior to death he showed weakness, emaciation, skin lesions, edema, psychosis, osteoporosis, low plasma protein, and low serum vitamins, but no anemia.

(5) *Reversal of intestinal loop.*—Occasionally a surgeon may, by error, reverse the direction of an intestinal loop. In other instances, a surgically excised viscus, such as the stomach or esophagus, may require replacement by a reversed segment of colon or intestine. It is important to learn the fate of these loops and to know whether they will transport intestinal contents.

Reversed loops have been studied by Singleton and Rowe. Their experiments confirmed the finding of others that, in dogs, the direction of peristalsis in a loop of bowel remains constant. Therefore, in order to maintain the maximum efficiency of flow of intestinal contents, the normal position of the intestine should be maintained.

The contraction of any given loop of intestine, moreover, is a property of the loop itself and does not depend upon its position in the gastrointestinal tract. This was proved by some interesting experiments by Watkins and Mann. They found that the rate of contraction was constant for any given loop of intestine, regardless of whether it was in a normal or a transplanted position in another section of gastrointestinal tract. The contractions were most frequent in the upper intestine and decreased progressively as the level became lower.

3. Enteroanastomosis without resection of area of obstruction.—This method generally is inferior to others unless the segment bearing the obstruction is to be resected at a second stage. Ileotransverse colostomy represents a typical application of this procedure.

Ileocolostomies are either side-to-side or end-to-side. The decision must be made on the basis of whether complete defunctioning of the distal ileum is necessary.

behind the anastomosis. It cannot be closed properly; herniation of a loop of small bowel through it may cause a postoperative obstruction (Fig. 30).

The presence of a side-tracked loop of bowel that is not resected later after a side-to-side anastomosis may lead to serious complications. A very short loop may produce no symptoms. When the loop is larger, a series of symptoms is likely to be instituted that include colicky pain, distention,



Fig. 32.—X ray after gastroileostomy. Owing to previous peritonitis, adhesion was mistaken for ligament of Treitz at time of gastric resection for duodenal ulcer. Early postoperative diarrhea led to X ray, with demonstration of prompt passage of barium into cecum via gastroileostomy. Recovery followed revision of anastomosis.

nausea and vomiting, diarrhea, and anemia. The incidence of these changes after such operations is not known. Barker and Hummel found several patients in whom a severe macrocytic anemia developed after this operation. The side-tracked loops dilated and filled with intestinal contents. The anemia of blind loops has been explained by increasing utilization of vitamin B_{12} by bacteria in blind loops, according to Krevans, Conley and Sachs. The anemia therefore is quite similar to that which occurs after total gastrectomy.

The operation is usually done for cancer of the right colon and is the method of choice if the surgeon decides that one-stage resection and anastomosis carries too great a risk. If the ileocecal valve is incompetent, so that colonic contents flow back into the ileum, an ileocolostomy provides adequate decompression. Side-to-side ileocolostomy is the wisest procedure and is satisfactory except in the presence of perforation, when an end-to-side ileocolostomy is necessary.

Ileocolostomy is also required for some obstructing lesions of the terminal ileum. Of these, regional ileitis is the commonest. Side-to-side ileocolostomy



Fig. 31.—Blind pouches secondary to side-to-side anastomosis. Several years before, patient had had a two-stage right colectomy. Note dilated blind pouches of distal ileum and transverse colon on the left.

is the simplest and safest operation, but from the point of view of the long-term result, it is generally believed to be inferior to resection or end-to-side ileocolostomy with exclusion of the inflammatory process, unless the inflammation appears completely inactive and the obstruction due to scar.

METHODS.—(1) *Side-to-side ileocolostomy.*—A left paramedian incision is made. A loop of ileum 12 to 18 inches proximal to the obstructing lesion is identified. If obstruction is due to cancer, the anastomosis is placed in the transverse colon at a point 8 to 10 inches beyond the obstructing lesion. A two-layer open anastomosis is made. The outer row is of interrupted cotton and the inner of 000 atraumatic catgut. By this procedure a large trap is left

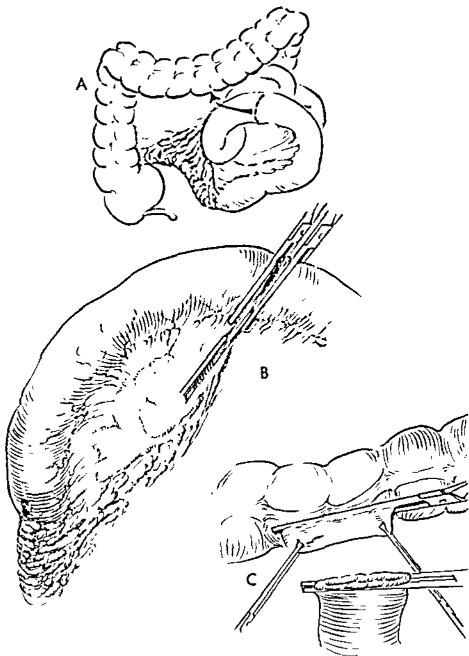


Fig. 33.—End-to-side anastomosis, illustrating ileotransverse colostomy with exclusion of terminal ileum. **A**, terminal ileum is divided a foot or more above obvious enteritis. If any evidence of ileitis is discovered at point of division, higher level should be chosen. **B**, ileum is divided with scalpel between Allen clamps. **C**, section of lateral wall of transverse colon is elevated with Allis clamps and Allen clamp applied (**continued**).

Clinically, the commonest serious side-tracking operation in continuity follows a surgical error in which, after an operation on the stomach, a gastroileostomy is performed rather than a gastrojejunostomy. Severe diarrhea, malnutrition, vitamin deficiencies, and weight loss follow rapidly. Fortunately the diagnosis is easy, since a barium meal can be observed to pass rapidly through a short segment of ileum into the intestine (Fig. 32).

In most cases in which blind loops have been left in continuity, barium studies will show retention and the loop can be outlined. Revision of the anastomosis or resection of the blind loop is necessary for the relief of symptoms.

(2) *End-to-side ileocolostomy* (Fig. 33).—The sections of intestine and colon are chosen in the same fashion. The ileum is divided between clamps. The proximal end is anastomosed to the colon by an open two-layer suture. Whenever the diameter of the ileum is small, it is better to make the inner layer of interrupted 000 atraumatic catgut and the outer of interrupted cotton. The distal end is either turned in with three layers of sutures, if obstruction is not complete, or brought out through a stab wound as a mucous fistula, if the bowel is completely obstructed.

4. ESTABLISHMENT OF SURGICAL VENT OR ARTIFICIAL ANUS.—This is an effective measure for the relief of obstruction in the colon, but introduces the problems of a high intestinal fistula when used in the small intestine.

METHODS.—The common methods that will be discussed here include (1) catheter enterostomy, of which the Witzel type is most applicable to intestinal obstruction; (2) terminal ileostomy, which may be either single-barreled or loop; (3) cecostomy; (4) transverse colostomy, and (5) obstructive (or Mikulicz) resection.

(1) *Catheter enterostomy*.—Enterostomy was accepted for many years as the most suitable operation for acute simple small-intestinal obstruction. It consisted essentially of the introduction of a catheter into a loop of distended intestine proximal to the obstruction.

At the present time enterostomy is a rare operation. As a prophylactic method, it may be used to prevent distention above an anastomosis. For example, Benson recommended it highly after resection and anastomosis for congenital atresia. It is certain that prophylactic or therapeutic use of the Levin and intestinal tubes have rendered most enterostomies unnecessary.

Preferably the catheter should be placed in the lowest distended loop. An abdominal X ray may aid, though when the operation is done under local anesthesia, the selection of the best possible loop is a matter of chance. The characteristic feature of the Witzel enterostomy is the construction of a serosal tunnel about the catheter that allows rapid closure of the fistula as soon as the tube is withdrawn. The technique has been described by Linton.

TECHNIQUE (Fig. 34).—A distended loop of small intestine is delivered, emptied by manual pressure. A rubber-covered intestinal clamp is applied. A purse-string suture is inserted, the bowel opened, and a No. 20 to 24 whistle-tip catheter inserted. The suture is snugged up and tied and the catheter sewed in with it. With a second suture the catheter is enclosed in a serosal tunnel. If possible the tube is drawn through omentum. The abdominal wall is then closed.

The catheter is allowed to drain by gravity. Occasional irrigations are necessary. It may be withdrawn as soon as normal bowel movements recur.

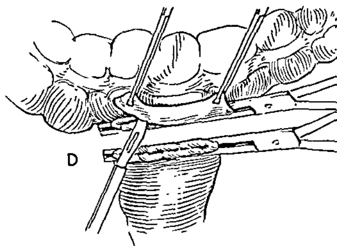
(2) *Terminal ileostomy.*—While an ileostomy may be either of the loop or of the single-barreled type, when it is used for intestinal obstruction, the loop ileostomy is usually employed. In this method, a loop of terminal ileum is brought out through a short incision and held in place by a glass rod passed through the mesentery. Though some surgeons have used it as a method of decompression in the presence of severe distention proximal to a cancer of the right colon, it should be noted that it introduces many complications that made the later resection much more difficult. For this reason it is not used in the Massachusetts General Hospital as a first-stage operation for cancer. The writer has used it occasionally in operations for combined intestinal obstruction and peritonitis.

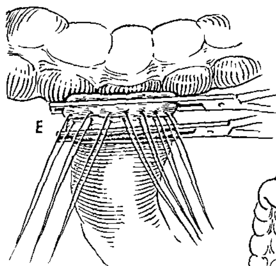
The common type of ileostomy is done in conjunction with a partial or total colectomy for ulcerative colitis or multiple polyposis and is a single-barreled ileostomy. Since intestinal obstruction is a frequent complication following ileostomy, the proper technique of the operation is shown in Figure 35.

(3) *Cecostomy.*—The earliest cecostomies consisted of exteriorization of the cecum, usually fixing it to the skin of the abdominal wall by sutures. The bowel then was opened widely. There are still occasional instances in which this is the wisest method. Claude Hunt recently has described this operation, which, by use of his special clamp, may be done nearly aseptically.

Since it is probable that some sepsis in the abdominal wall will follow, and quite unlikely that any cecostomy opening made by this method will close spontaneously, modifications that involve the use of a tube leading from the cecum have become much more popular. The tubes used include rubber, glass, and Pezzer or other large catheters. Most of the smaller vents fail to function well, since the tube plugs with feces or, as the cecum collapses, with mucosa. A satisfactory method of cecostomy is that described by Allen and the author, based on the modification of Gibson's original technique.

TECHNIQUE (Fig. 36).—If the patient is very ill, local anesthesia is used. A McBurney incision is made, keeping to the outer side of the rectus fascia





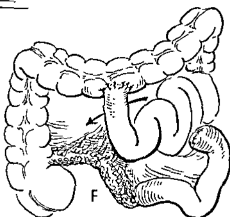


Fig. 33 (cont.).—D, colon is opened. **E,** open anastomosis is performed by technique illustrated in Figure 26. **F,** anastomosis has been completed. If there is no significant obstruction, distal end of ileum may be turned in. If acute obstruction is present, it must be brought out as mucous fistula. Trap left after this operation, shown by arrow, is difficult to close, and small intestine may herniate behind it later.

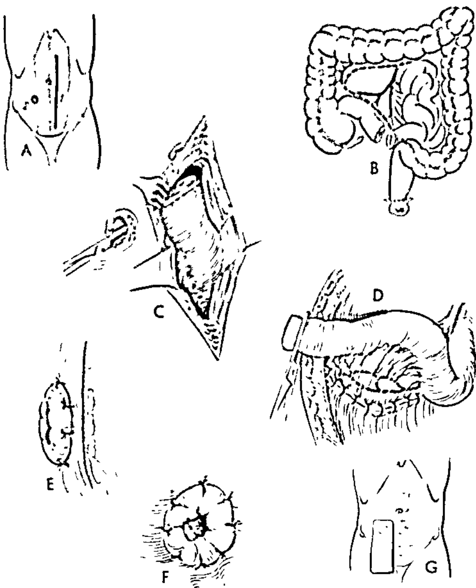


Fig. 35.—End ileostomy. This type is usually done in conjunction with total or subtotal colectomy for ulcerative colitis. **A**, colectomy is performed through left paramedian incision. Circular incision 2 for ileostomy is made after colectomy has been completed. **B**, ileum is divided 6 to 10 inches above ileocecal valve or higher if terminal ileum is involved. Generous section of mesentery of right colon and terminal ileum, shown by dotted line, is left to aid in later peritonealization and closure of trap lateral to ileostomy. **C**, at conclusion of colectomy, circular incision for ileostomy is made and ileum withdrawn. **D**, ileum is withdrawn about an inch and cut edge of ileal mesentery sutured by multiple interrupted cotton sutures to lateral and posterior peritoneum, completely closing lateral gutter. **E**, after closure of paramedian incision, clamp is removed from ileum and mucosa joined to skin by interrupted catgut sutures. **F**, completed stoma. **G**, plastic bag is attached immediately.

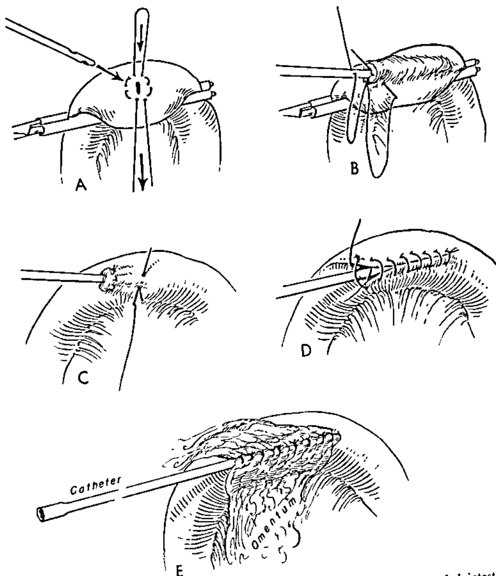


Fig. 34.—Catheter ileostomy (Witzel technique). **A,** loop of distended intestine is emptied manually and rubber-covered clamp applied. Purse-string suture is laid, intestine opened, and No. 20 whistle-tip catheter inserted. **B,** catheter is sutured in position. **C,** catheter is enfolded in serosal tunnel that is started just proximal to catheter. **D,** completion of tunnel. **E,** further reinforcement may be secured with omentum

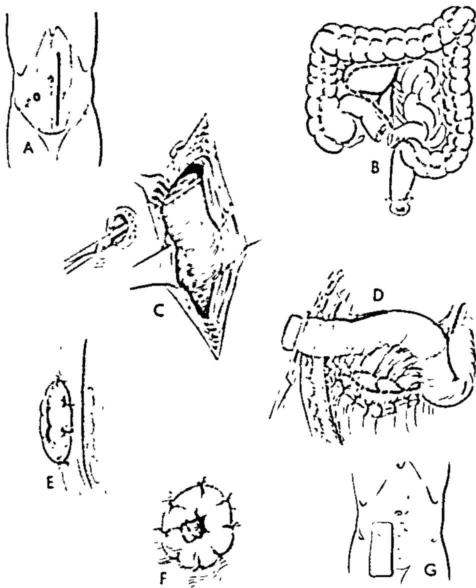


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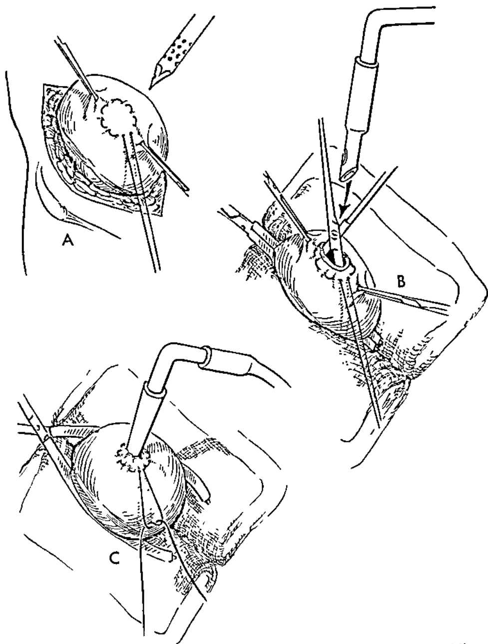


Fig. 36.—Modified Gibson tube cecostomy. **A**, distended cecum is delivered through McBurney incision. It will be decompressed with sharp trochar, through previously inserted 00 plain atraumatic catgut purse-string suture. For purposes of orientation, pads protecting incision are not shown. **B**, collapsed cecum is retained by rubber-covered clamp. Cecum is opened and rubber tube that is attached to right angle tube is inserted. **C**, suture is tightened as clamp is loosened, allowing tube to pass deeper into cecum **(continued)**.

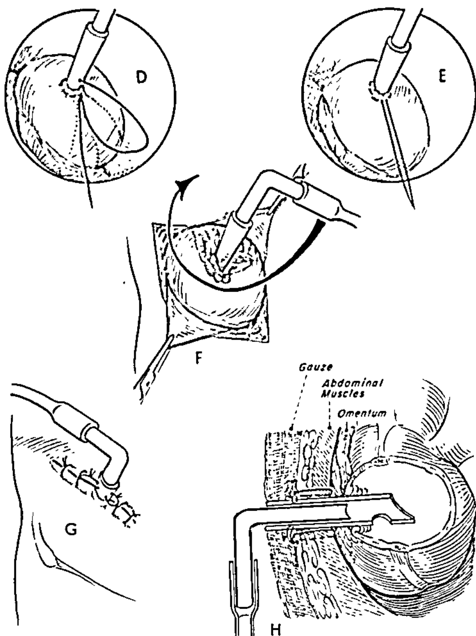


Fig. 36 (cont.).—**D,** purse-string suture has been tied, and tube now is anchored in place **E,** second purse-string suture of 00 atraumatic catgut further inverts tube into cecum. **F,** if easily available, omentum is sutured about tube; glass tube is then rotated in rubber tube to point where it will lie in proper position on abdominal wall. **G,** incision has been closed in layers. Tube is securely anchored by two wire sutures. **H,** cross section shows tube in cecum Glass tube prevents kinking or collapse of tube in abdominal wall.

whenever possible. A portion of the distended cecum is delivered, and the wound edges are protected with gauze. A purse-string suture of 0 plain catgut is placed and the cecum elevated by two Allis clamps. A sharp suction trochar is then introduced through the purse-string suture, and the cecum is aspirated. After the cecum is decompressed, a rubber-covered clamp can be applied to its wall and only minimum contamination should occur.

The cecum then is opened and the decompression tube inserted. This is made of rubber, ½ to ¾ inch in diameter, and must be soft and flexible but must not kink easily. It is attached to a right-angle glass tube, which in turn is connected to a drainage bottle. The tube is arranged in such a fashion that only the rubber tube is present within the cecum, while the glass tube runs through the abdominal wall as a support to prevent kinking.

As the tube is inserted, the purse-string is tightened, and simultaneously the rubber-covered clamp is removed so that the tube can be introduced for the proper distance. The same suture is then passed through the wall of the tube and tied. Inversion of the cecum is completed by two other purse-string sutures. It is possible to protect the suture line with omentum but inadvisable if the transverse colon is to be mobilized later.

The incision is then closed in layers with catgut and with silk to the skin. One of the skin sutures is passed through the rubber as an additional protection to maintain the position of the tube.

Postoperatively, gravity drainage is maintained for 24 hours. Thereafter, mechanical irrigation with saline solution or dilute magnesium sulfate can be carried out. Usually, edema about the obstructing lesion subsides in a few days, so that bowel movements are re-established. Introduction of a suspension of phthalylsulfathiazole into the cecostomy stoma will facilitate the preparation of the colon for resection.

These measures nearly always clean the bowel satisfactorily. If they fail, as they may if inspissated barium is present, a secondary transverse colostomy will be necessary. It is well to remember that failure to secure deflation may be due to other causes. For example, there may be a concomitant small-bowel obstruction, or there may be a volvulus of the sigmoid so that deflation of the closed loop cannot be effected by a transverse colostomy.

COMPLICATIONS.—*Wound sepsis* always occurs, because completely aseptic decompression is impossible by this technique. It is nearly always controlled easily but does not subside entirely until the tube is removed. *Pressure necrosis* of the cecal wall may occur if the tube is left in place too long. The tube is tolerated well for two weeks, but after that time it is dangerous, particularly if it is large or stiff. Perforation of the ascending colon

or hepatic flexure may occur if the tube is long, stiff, and sharp-pointed. Complete *prolapse* of the cecum through the cecostomy incision is uncommon; it requires operative closure or even resection of the involved segment. *Hernia in scar* is quite common, though it is rarely troublesome enough to require repair. *Failure of the cecostomy incision to close* spontaneously occurs occasionally. It is wise to wait a minimum of three months before carrying out operative closure; often final cessation of drainage occurs long thereafter. When the mucosa projects above the skin margin, it is certain that spontaneous closure will not occur and operation is indicated.

(4) *Colostomy.*—Types: Colostomies are described by designating the section of colon in which the stoma is made and the method used in construction. In *loop colostomies* a section of distended colon is exteriorized and partially or completely divided at a later time. In *double-barreled colostomies* the obstructed colon is divided and two stomas brought out of the abdominal wall. The two limbs of colon may be sutured together, forming a spur, by the Mikulicz technique, the two stomas being allowed to lie in apposition. Devine formed a spur but separated the stomas by a skin bridge. *Single-barreled colostomies* are made when the bowel distal to the stoma has been completely excised or when the obstructing lesion has been resected and the distal colon turned in.

When colostomies are performed for acute intestinal obstruction, they nearly always are of the loop or double-barreled type. The loop is the simplest form but does not defunction the distal colon as well as the divided double-barreled type. Usually the stoma is made in the transverse colon.

For transverse colostomy, an abdominal X ray must be taken before operation. It is important to locate the transverse colon as accurately as possible, since it is not always easy to identify it when the abdomen is greatly distended. A lead marker on the umbilicus makes a simple guide. It is then necessary to decide whether the stoma is to be made on the right or on the left side. If it is made on the right, greater mobility will be preserved for a later attack on the left side of the colon. One objection to the right-sided colostomy is that the nearer the opening is to the cecum, the more liquid is the fecal content, and colostomy control becomes more difficult. However, this is not a serious problem for the short time most of these colostomy stomas exist.

The most serious objection to a colostomy in the right upper quadrant is that gallbladder disease may force operative intervention when the stoma is functioning. If it does, the technical problem is difficult. Consequently, if there is a history indicative of gallstones, it is well to place the stoma well away from any incision that would be required for gallbladder surgery and put it either in the mid-line or to the left.

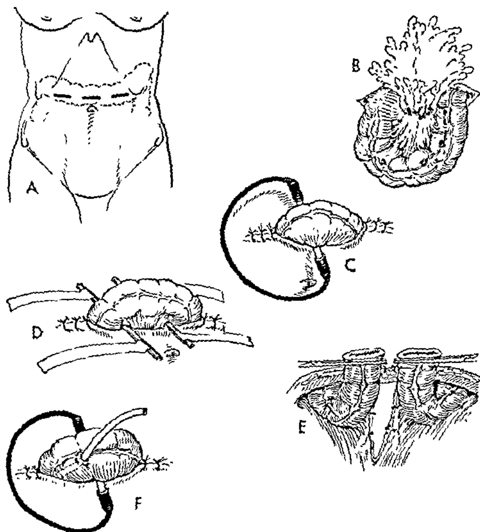


Fig. 37.—Transverse colostomy. A, various incisions that may be used. Transverse is preferable to vertical. B, omentum has been detached from section of colon and will be returned to peritoneal cavity. Care must be taken to avoid underlying mesentery of colon. C, simple loop colostomy. It is secured in position by glass rod passed through mesentery just below colon. D, method of separating the colostomy limbs with loop colostomy. Longer incision is necessary. Two glass rods are inserted and held apart by adhesive strips. Loop colostomies are generally opened 24 hours later and colon completely divided if necessary, a few days later, with cautery. E, completely defunctioning colostomy has been made by division of two limbs and mesentery. The two limbs are brought out through lateral margins, of incision. F, method of immediate decompression of loop colostomy by large catheter. This is done as soon as abdomen is closed if there is great distention of colon.

TECHNIQUE (Fig. 37).—A transverse incision is made. The distended transverse colon is identified and withdrawn Omentum is detached and returned to the peritoneal cavity. A glass rod is passed immediately under the bowel to prevent retraction into the peritoneal cavity. Assuming that the incision has been relatively short, no further wound closure is necessary. If the colon is greatly distended, it should be decompressed at once to prevent perforation of the cecum. A large catheter can be inserted into the proximal portion of the colon and anchored by a purse-string suture. By this means nearly aseptic decompression can be accomplished. In 24 hours, when the peritoneal cavity is completely sealed off, the colostomy stoma can be opened widely with a transverse incision

When the obstruction is not so acute, a more satisfactory colostomy can be done by a complete division of the transverse incision at the time of the operation, a skin bridge being sutured between the two stomas. This is the procedure of choice whenever complete defunctioning of the distal colon is desired and possible. There is no advantage to doing any of the more complicated procedures, such as the Devine colostomy.

COMPLICATIONS (Fig. 38).—*Prolapse* may involve either the proximal or the distal loop of transverse colon. It is commonest when the colon is redundant. Too tight closure of the peritoneal cavity may lead to this complication. While small prolapses will cause no symptoms, large ones are serious. When the patient is seen early, manual reduction may be used if the prolapse is large; it may be replaced within the peritoneal cavity if there has been no fecal contamination or amputated if the colostomy stoma has already functioned. At times an irreducible prolapse becomes gangrenous and requires resection.

Herniation of a loop of small bowel at the site of the colostomy is not infrequent because of the underlying distention. Immediate operative replacement is necessary. The omentum also may herniate and even carry a portion of the wall of the stomach with it if a large amount has prolapsed.

Gangrene of either proximal or distal stoma of a divided colon may occur if the mesentery has been divided too deeply.

Retraction may occur with any type of stoma. Most commonly it occurs with an end colostomy and follows inadequate mobilization of the colon. It usually appears shortly after operation. Early operative revision is desirable before fecal contamination occurs. Loop colostomy stomas regularly retract several weeks after operation; in fact, spontaneous bowel movements occasionally may be recovered if the distal obstruction has been relieved.

Volvulus of the small intestine may occur about a sigmoid colostomy stoma if the gutter has not been closed tightly; such a herniation is rare about the site of a transverse colostomy.

Other complications that occur later include contraction of the stoma, fis-

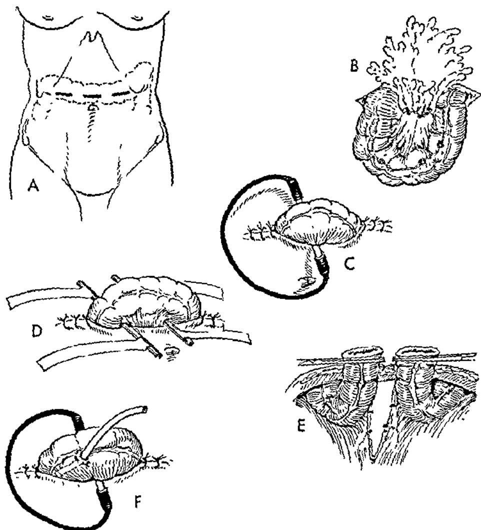


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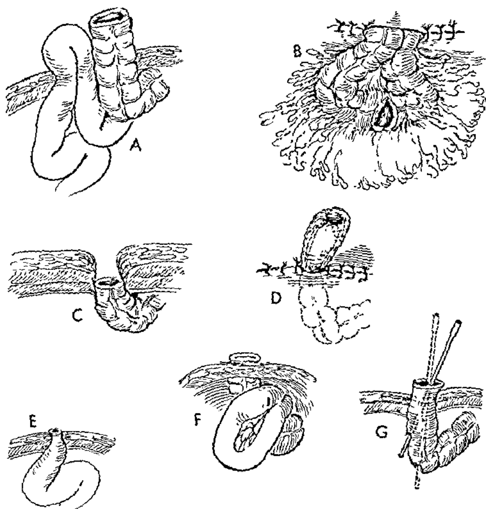


Fig. 38.—Complications of colostomy. A, herniation of loop of small intestine through colostomy incision. B, prolapse of redundant transverse colon and omentum at site of transverse colostomy. C, retraction of stoma into abdominal wall. D, prolapse. E, stenosis. This occurs at level of skin and anterior rectus fascia. F, herniation of loop of small intestine through gutter lateral to colostomy. G, perforation by catheter. This usually occurs just below skin level or at base of sigmoid loop.

tula formation, and fecal impaction. Local trauma from a catheter may lead to ulceration, hemorrhage, or perforation of the colostomy.

Closure: The colostomy stoma may be closed as soon as the primary lesion has been resected and the anastomosis is healed. The integrity of the anastomosis can be established by irrigation with salt solution or by a thin barium enema. If the barium demonstrates any leakage, closure must be delayed for a month and the barium enema repeated at that time. The usual time for closure is 10 days to three weeks after the resection.

The colostomy opening is mobilized completely from the abdominal wall. If the bowel was only partially divided, and the mucosal edema has subsided, the mucosal margins can be excised and a two-layer plastic closure carried out (Fig. 39). If the bowel was essentially or completely divided, clamps are applied across the colon in a normal area, the stoma resected, and an end-to-end anastomosis done. This is made with an inner layer of fine catgut sutures, interrupted or continuous, according to the size of the lumen, and an outer layer of interrupted cotton sutures. The colon is then returned to the peritoneal cavity. The peritoneum is closed with catgut and the fascia with the same type of sutures. If there is a deep layer of subcutaneous fat, delayed closure of the skin is wise.

Cecostomy or colostomy.—In some respects it may be said that cecostomy and colostomy are techniques that compete in favor as a preliminary operation for obstructing lesions of the distal colon and rectum. Yet the surgeon should be able to determine precisely which procedure is the better for the individual case and be familiar with the advantages and disadvantages of both. The technical problems are less troublesome with a transverse colostomy, and published mortality figures indicate a definite advantage in favor of colostomy as a preliminary procedure. Certainly the inexperienced surgeon will find colostomy a much less tricky procedure.

The arguments in favor of cecostomy, performed as demonstrated above, are as follows.

1. The operation is simple and easily tolerated by a sick patient. Thus an extremely ill patient can have a lifesaving cecostomy performed under procaine hydrochloride (Novocaine) anesthesia; transverse colostomy is more difficult to carry out under local anesthesia. Also, a distended cecum is easier to locate than a distended transverse colon. The cecum need not be delivered in its entirety through the abdominal wall, as the colon must if a colostomy is done.

2. When large-bowel obstruction produces rupture of the colon from increasing tension, the cecum is the first portion to rupture. It is, therefore, more logical to observe the cecum at the time of operation to be sure the serosa is intact and viable.

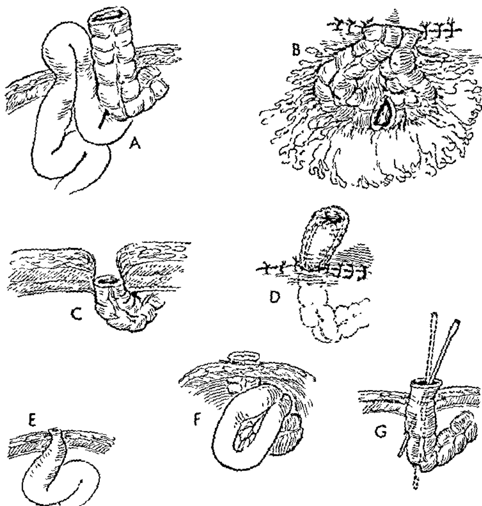


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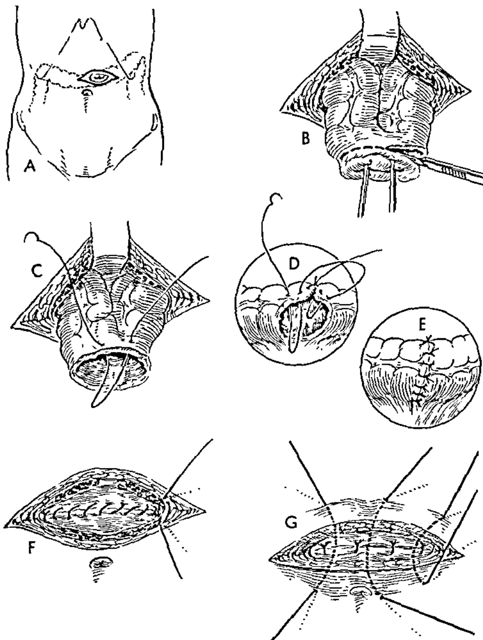


Fig. 39.—Plastic closure of loop colostomy stoma. **A**, stoma is elevated with Allis clamps, old scar excised, and incision carried into peritoneal cavity. **B**, colon has been freed completely. Margin of stoma now is excised. **C**, lumen of colon is shown to be adequate and plastic closure therefore feasible. Connell suture of 000 atraumatic catgut is started. **D**, continuation of inner row. **E**, outer row of interrupted cotton sutures completes closure. **F**, colon has been replaced within peritoneal cavity and peritoneum closed. **G**, wire retention sutures are placed through anterior fascia. If incision is deep, gauze pack is inserted for delayed closure 48 hours later. If incision is shallow, it is closed primarily.

3. Preparation of the colon for definitive surgery can be accomplished in a satisfactory manner by cecostomy, though admittedly not as perfectly as by a transverse colostomy. On the other hand, if colostomy is necessary it can be done much more easily if the obstruction has been relieved by cecostomy. If there is much solid fecal matter in the colon, removal may be



Fig. 40.—Preparation of colon for resection after cecostomy by Millet's technique. Miller-Abbott tube has been passed through cecostomy tube down to obstruction and is used as irrigating device.

aided by the method developed by Dr. J. B. Millet, a former surgical resident at Massachusetts General Hospital. A Miller-Abbott tube is passed through the cecostomy tube and the balloon inflated. The tip of the tube is promptly carried around to the obstruction. In this position it can be used to irrigate the colon back through the cecostomy tube (Fig. 40).

4. The transverse colon is left intact for any further anastomotic procedures. In many instances, after left colectomy it is necessary to anastomose the transverse colon to the rectum. This operation may become difficult

if a short transverse colon has been fixed by a colostomy. The same unfortunate result may occur if the colon is of normal length but the colostomy stoma is placed improperly.

5. Spontaneous closure of the cecostomy stoma may be expected in nearly all cases, a third operative procedure thereby being avoided. In a series of 250 cecostomies carried out in the Massachusetts General Hospital, 94 per cent of the stomas closed spontaneously.

The arguments that favor transverse colostomy rather than cecostomy are as follows:

1. The bowel is defunctioned completely by a colostomy, while it merely is decompressed by a cecostomy. This means that preparation of the distal bowel is much better with a colostomy.

2. After cecostomy there usually is a rise in temperature for several days; this is unusual after colostomy. It must be said, however, that peritoneal contamination due to the cecostomy is rarely of any significance.

3. The colon can be decompressed as rapidly after a colostomy as after a cecostomy, since a catheter can be inserted on the operating table.

4. A cecostomy tube often cannot be maintained in position as long as it is necessary. Furthermore, left in too long, a hard tube may cause pressure necrosis of the cecal wall. This difficulty never occurs with transverse colostomy.

The selection of the proper operation is made by the writer on the following considerations. In general, cecostomy is preferred for obstructing lesions of the left colon, it being realized that in a few instances this operation must be followed by transverse colostomy. Transverse colostomy should be the primary operation if the colon is packed with solid feces or with a barium mixture after inadvertent administration by mouth. Diverticulitis or perforated cancer of the left colon with a local abscess also usually requires a transverse colostomy, since complete defunctioning is desired and the period before definitive surgery is likely to be protracted. If there is acute obstruction from cancer of the rectum, cecostomy is preferred, since a transverse colostomy followed by the usual Miles' procedure leaves an awkward problem of two colonic stomas.

For cancer of the hepatic flexure or right transverse colon, cecostomy provides excellent decompression but complicates the later resection. Consequently a one-stage resection and anastomosis or ileocolostomy as the first stage of a two-stage resection is preferred.

(5) *Obstructive resection* (Fig. 41).—The "obstructive resection" is a modification of the operation developed by Mikulicz and Paul. The term refers to two of the important features of the operation—resection of the bowel and temporary obstruction of the colon produced by a clamp and

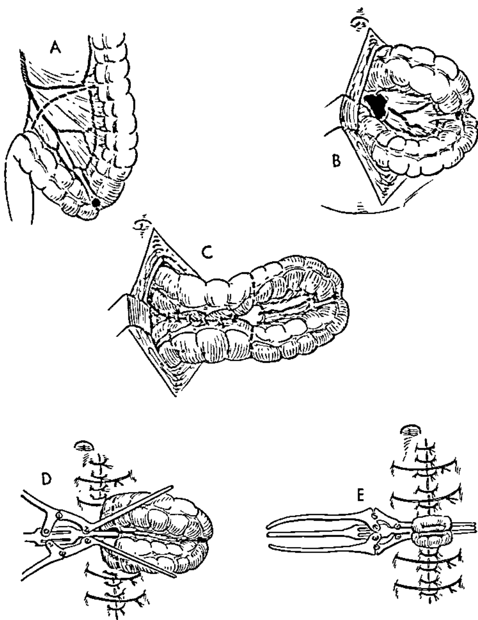


Fig. 41.—Obstructive resection. Resection is shown for cancer of sigmoid. **A**, extent of resection. Superior hemorrhoidal artery is left intact to provide adequate blood supply. Descending colon and intraperitoneal rectum must be mobilized. **B**, mesentery has been divided. Antimesenteric margins of colon are sutured to form spur. **C**, spur completed. **D**, incision has been closed. Rankin clamp is applied. **E**, exteriorized segment is amputated.

maintained for several hours, until the peritoneal cavity has become sealed off by adhesions.

This operation has been used widely as a definitive method for treatment of cancer of the colon, though it has been superseded in the Massachusetts General Hospital by resection and primary anastomosis. Insofar as the management of acute intestinal obstruction is concerned, it occasionally may be of value. Concomitant obstruction and perforation of a cancer of the colon, perforated diverticulitis with obstruction, gangrenous volvulus of the sigmoid, a gangrenous intussusception, or a strangulated hernia that requires resection of the ileum may indicate its use when the patient is in too poor a condition for an anastomosis. It should not be employed in the small intestine except in the terminal ileum, since serious electrolyte disturbances follow creation of a complete high enteric stoma. Some pediatric surgeons, such as Gross, use the Mikulicz procedure frequently for lesions of the distal ileum and, on occasions, even for more proximal lesions.

TECHNIQUE.—After identification of the lesion, the bowel must be mobilized widely enough to allow the entire abnormal section to be exteriorized and normal bowel to extrude above the surface of the skin without tension. Failure to do this may lead to a chain of disasters that include retraction of the stoma, wound sepsis, and peritonitis.

When one is dealing with obstructed colon, it may not be possible to form a spur by suturing the two limbs of the colon together. Consequently, clamps are applied in normal bowel an inch above the level of the skin edge, and the bowel is divided with the cautery after the mesentery has been cut at an appropriate level. The stomas are preferably brought out through a stab wound and the incision closed. The proximal clamp is removed 24 hours later and the distal several days afterward. However, if the obstruction is acute, the proximal colon should be decompressed immediately by suturing a catheter in the stoma. One can do this aseptically, avoiding contamination. At a later date, when the patient has convalesced, the stomas are resected and continuity of the bowel re-established by an end-to-end anastomosis.

Many surgeons who approve of this type of resection prefer to make a spur whenever possible, sewing the antimesenteric margins of the two limbs of the colon with a continuous catgut suture. A spur can always be made in the small intestine because of its mobility. The spur can then be cut in a few days by the application of Kocher or special clamps. Normal bowel movements may thereafter be established spontaneously. Usually a final closure is necessary, but this usually is a less formidable procedure than resection and anastomosis.

However, there are certain features that tend to complicate spur formation and crushing. A loop of small intestine may insinuate itself between

the colonic limbs, or the spur suture may dehisce, so that the crushing clamp is applied to intestine as well as to colon. The clamp may be applied to the mesentery of the colon, where it is very painful and may cause *hemorrhage*.

For these reasons, while obstructive resection may relieve obstruction expeditiously, it can institute technical problems that make convalescence difficult, as well as compromise the *amount of colon and mesentery* that is desirable to remove.

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Weighted tubes will pass through the pylorus and decompress the duodenum. However, duodenal decompression actually occurs in the great majority of patients who have Levin tubes inserted, since there is bile in the aspirated fluid, in nearly every case.

2. LONG INTESTINAL TUBES.—The common tube now in use was introduced by Miller and Abbott and modified later by Johnston, Harris, Cantor, and Smith.

The Miller-Abbott tube is the prototype of all the intestinal tubes. It is a double-lumen tube, one lumen serving as a means of aspiration and the other for inflation of the balloon. Aspiration is effected through the metal tip and through holes just proximal to the balloon. The two lumens are identified by name at the upper end of the tube.

Since this tube passes out of the stomach with difficulty, several attempts have been made to make it more effective. The best method is to insert about 4 cc. of mercury into the balloon. This will facilitate passage through the pylorus. Another is to use a stylet that has been devised by Abbott to manipulate the tube through the pylorus, though this is not as satisfactory a procedure.

The tube is used in the following manner. Two per cent tetracaine (Pontocaine) may be used in the nose and pharynx, though this usually is not necessary. The well-lubricated collapsed balloon is passed through the wider nostril into the stomach to the 60 cm. mark, the patient sipping water as the tube is swallowed. The distance in an adult to the first part of the duodenum is about 75 cm. With the tube in the stomach, the stomach is aspirated; then 2 to 3 cc. of mercury is injected into the tube leading to the balloon; about 10 cc. of air will be necessary to move the mercury through the tube into the balloon. Excess air is aspirated from the balloon. The patient then lies on his right side, and the tube is introduced under fluoroscopic guidance into the pyloric ring. Elevation of the feet often helps, and small sips of clear fluid may aid passage through the pylorus. After the tube is in the duodenum, the balloon is inflated with 10 to 20 cc. of air. Sometimes the tube progresses rapidly. If not, it is advanced by the physician or nurse 2 inches every two to four hours. After it reaches the upper jejunum it may be pushed more rapidly, but care must be taken that it does not coil in the stomach.

It may be very difficult to place the tip of the tube in the pylorus. If mercury is placed in the bag and the stomach filled with air or water, the bag may gravitate to the pylorus.

The Johnston tube is similar to the Miller-Abbott tube. The aspirating suction and bag inflation tubes are entirely separate, so that less chance for confusion occurs, and the greater diameter makes it more effective.

The Harris tube is, by contrast, a single-lumen tube. The tip is similar to

8

Intubation

A. TYPES OF TUBES

MANY TYPES AND METHODS OF intubation are available, but, in general terms, tubes may be divided into two groups: (1) gastroduodenal tubes, such as the Levin tube, and (2) long intestinal tubes (Fig. 42).

1. GASTRODUODENAL TUBES.—While numerous modifications of gastroduodenal tubes have been described, only one is in common use today. This is the Levin tube or some modification with a weighted tip such as that described by Paine. The Levin tube, passed through one nostril into the stomach, functions best when constant suction is applied to it, intermittent saline irrigations being given to maintain patency. It is the most effective tube to keep the stomach empty and its use is the most direct way to remove swallowed gas. The preoperative insertion of such tubes in all patients who are to have serious abdominal procedures essentially has eliminated the phenomena of postoperative pneumonia, which actually is aspiration pneumonia, and old-fashioned "gas pains," which are due to swallowed air.

Because it rests in the stomach, the greatest value of the Levin tube is as a means of prophylaxis of distention. It cannot deflate a distended small intestine except as fluid and gas regurgitate into the stomach. Since regurgitation of gas is easier than that of fluid, the Levin tube may be expected to give fairly good results when it is used for the treatment of postoperative distention, which apparently is chiefly gaseous in nature.

A No. 16 tube usually is tolerated well by the patient, though occasionally a smaller diameter will be necessary. The larger the diameter, the greater the efficiency. Plastic tubes are more comfortable than rubber but tend to kink more easily. The insertion of the Levin tube is much less onerous to the patient than that of any other type, and fewer complications follow its use.

those of the Miller-Abbott and Johnston tubes. A balloon containing about 4 to 6 cc. of mercury is tied just proximal to the metal tip and acts as a bolus which is propelled down the intestinal tract.

The Cantor tube has a mercury-containing bag that is the leading point of the tube. Suction holes in the single-lumen aspirating tube are immediately behind the balloon. On this tube, level "S" indicates that the tube is in the stomach, "P" that it is at the pylorus, and "O" that it is in the duodenum. After the tube is passed into the stomach, the stomach is emptied by aspiration and the tube advanced to position "P." The foot of the bed is raised 12 inches with the patient on the right side and almost face down. At the end of two hours the tube is advanced to "O" and the patient placed in Fowler's position, the tube being allowed to pass to the ligament of Treitz. Thereafter the patient is placed on his left side and the tube advanced about 4 inches an hour. At the 5-foot mark the tube is usually in the lower ileum.

The Grafton Smith tube carries a stylet and inflatable balloon. The tube is inserted through the patient's mouth and, by fluoroscopic manipulation of a semirigid stylet, is advanced through the stomach and duodenum. In many instances the jejunum can be intubated within a few minutes. This is the most rapid and effective method of intubation that has been described. The apparatus, on the other hand, is more complicated, and risk of perforation in unskilled hands would appear to be greater than with the other tubes.

B. MANAGEMENT OF INTUBATED PATIENTS

After intubation, improvement in the patient's condition will be manifested by relief of pain, subsiding distention, diminishing amounts of aspirate, the appearance of gas in the colon and diminution in size of the intestinal coils as seen by X-ray examination, and, finally, the presence of gas and feces in the rectum. Usually continuous aspiration is replaced after a few days, when improvement appears, by intermittent suction. Periods of two hours of aspiration alternate with similar periods in which no suction is employed. If no fluid collects in the interval period, the tube is allowed to drain by gravity for 24 hours, fluids are permitted by mouth, and then, if adequate function persists, the tube is withdrawn. Obviously, failure of the patient to improve indicates a slower schedule or operation.

C. INDICATIONS FOR GASTROINTESTINAL INTUBATION

In order that he make a proper selection, the surgeon must have a clear conception of what he expects to gain from the use of each specific method of intubation. The reasons that the tubes are used and their comparative advantages may be summarized as follows:

1. Prophylactic.—For prophylaxis, a tube is inserted before operation

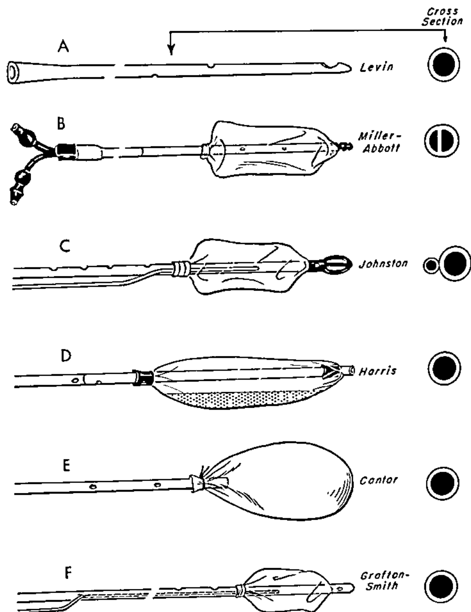


Fig. 42.—Gastric and intestinal tubes.

tion to be manipulated through the pylorus at the time of operation or advanced down the bowel if necessary at a later date.

(*b*) *To facilitate operative procedures.*—McKittrick has pointed out that the whole small intestine may be fluted easily on an intestinal tube, so that, at laparotomy, it may be kept out of the surgeon's way with the greatest ease. This is particularly advantageous in instances of total colectomy for ulcerative colitis. The intestinal tube also furnishes an easy method of orientation in difficult operations for small-intestinal obstruction. If the tube has been passed into the upper jejunum, the surgeon can readily locate the ligament of Treitz and can localize the points of obstruction much more easily. The long tube is also an effective means by which the intestine can be emptied of its contents at laparotomy.

(*c*) *For feeding purposes.*—Occasionally, an intestinal tube may be passed through an obstructed gastroenterostomy stoma, furnishing a means for alimentation until edema about the stoma subsides.

(*d*) *To treat ileus.*—This, of course, is by far the most important use of the tubes. Their value is well established in paralytic ileus and in early postoperative ileus. As an adjunct in therapy of acute mechanical obstruction, the tubes are important; as a sole therapeutic agent, some surgeons believe that they are effective and others, on the contrary, believe that they are dangerous.

Surgeons vary considerably in their attitudes about therapeutic intubation; no general agreement exists. Some of the opinions will be cited here. However, the surgeon must realize that in consideration of the individual patient, generalizations are dangerous. There is no substitute for the good judgment needed to make the choice fit each case.

It is agreed that intubation is of great value in the treatment of *paralytic ileus*. This method fortunately has replaced the older procedures of enterostomy, which were nearly uniformly unsuccessful.

If the diagnosis is made early, when distention is due chiefly to swallowed air, gastroduodenal decompression by the Levin tube will be satisfactory. Since distention usually is severe before treatment is begun, an intestinal tube should be used at once.

Intestinal intubation is difficult in any case of paralytic ileus and becomes harder as distention increases. Consequently, early treatment is imperative and the tube should be passed beyond the ligament of Treitz as rapidly as possible. Frequently this cannot be accomplished, and the surgeon must gain what he can from gastroduodenal decompression.

There is a close relationship between paralytic and mechanical ileus, which will be discussed in more detail in Chapter 23. Here it should be stated

with the expectation that the chances of postoperative paralytic ileus, distention, or actual mechanical obstruction will be diminished. A large amount of air may be pumped into the stomach during anesthesia, especially if the patient is receiving muscle relaxants and positive pressure is employed in the respirator. Soon after operation aerophagia is a common phenomenon. The introduction of a Levin tube before operation, and keeping it on suction for one or more days after operation, will obviate many of the hazards introduced by this air.

In some instances, an intestinal anastomosis may be contemplated, and the surgeon desires decompression of the proximal intestine. Under these circumstances, he may pass an intestinal tube before operation and position it above the anastomosis at the time of surgery. Such a maneuver may be carried out with resection of the right colon for cancer.

If the surgeon uses a long tube prophylactically, he must realize that the stomach may fill with swallowed air and gastric juice that cannot be aspirated from the tip of the tube. Unless he wishes concomitantly to pass a Levin tube, which produces an uncomfortable double intubation, there must be holes cut far back from the tip of the long tube, which will diminish the effectiveness of suction at the tip. This is a strong objection to the prophylactic use of the long tube. The writer has encountered so many problems of this type that he prefers the Levin tube and rarely uses an intestinal tube prophylactically before colon resection in the absence of obstruction.

It must be admitted that many able surgeons never use prophylactic intubation of any type. Certainly expert anesthesia and dextrous surgery reduce the need for it, but the average surgeon will find that the best means to prevent postoperative distention and ileus is prophylactic use of the Levin tube.

2. Therapeutic.—The tubes perform certain specific therapeutic functions. They are as follows:

(*a*) *To empty the stomach prior to operation.*—It has already been emphasized that aspiration becomes much more important in patients with intestinal obstruction, since relaxation of the pyloric and cardiac sphincters under anesthesia may lead to profuse vomiting, so that the patient may drown in his own gastric contents.

Preliminary aspiration of the stomach may be done by any type of tube, though the larger the lumen, the more effective the procedure. A tube may not be completely effective, however, if the stomach is full of debris, and the anesthetist often should insert a cuffed intratracheal tube under topical anesthesia before proceeding with his general anesthesia.

In cases of intestinal obstruction, an intestinal tube has an advantage over a Levin tube as a means to decompress the stomach, since it is then in posi-

Paine, in a thoughtful appraisal of the problem of intubation, stated that he has "never been convinced that the results obtained by using the longer tubes, such as the Miller-Abbott or Cantor tube, are worth the increased amount of time, effort and bother which their proper use demands, as compared to the results obtained by the shorter Levin tube with a weighted tip." Moses attributes his low mortality to several factors, including avoidance of the Miller-Abbott tube, with its attendant false sense of security.

Most surgeons, however, prefer to use long intestinal tubes and, understandably enough, are impressed most favorably by tubes developed in their own clinics.

In the Massachusetts General Hospital, following McKittrick's program, an intestinal tube is passed into the stomach before operation for acute mechanical small-intestinal obstruction. Cantor of Harris tubes are preferred. In cases of early or of strangulating obstruction, no attempt is made to pass the tube through the pylorus before operation, because valuable time will be wasted. In some instances it is manipulated past the ligament of Treitz on the operating table or allowed to pass into the small intestine postoperatively. If the obstruction is late and simple, the long tube is, if possible, manipulated through the pylorus into the upper jejunum in the hours or days that precede operation.

(2) *Obstruction of colon.* This is, in general, treated by early operation, the stomach being emptied by a Levin tube. There is one important exception to this rule; the patient with cancer of the cecum or an obstructed right colon who demonstrates free reflux through an incompetent ileocecal valve often can have preliminary decompression by the long tube, since this will allow a one-stage right colectomy to be done with ease.

When the ileocecal valve is competent and distention is limited to the colon, intubation is dangerous and should not be used. The delay incidental to passage of the tube through the ileocecal valve may invite perforation of the cecum. Moreover, the contents of the colon are difficult to aspirate through any intestinal tube, even if it enters the colon. Consequently, in our hospital, a Levin tube usually is used preparatory to a cecostomy or transverse colostomy for relief of the distention.

The author personally is inclined toward the use of the Levin tube and operative decompression of the intestine rather than use of the intestinal tubes. In a series of 223 episodes of acute obstruction of intestine or colon, intestinal tubes were used in 38, and Levin tubes in 153. In only nine of the 38 was it possible to be sure that the intestinal tube clearly showed an advantage over the Levin tube.

3. Other uses of tubes.—The intestinal tubes have also been used for other purposes. Aspiration of the intestinal contents at various levels

that laparotomy will finally be necessary in a few patients who have paralytic ileus and fail to respond to intubation.

Postoperative ileus usually begins as a paralytic type, progressing, unless effectively treated, to mechanical obstruction. As emphasized above, prophylactic Levin tube intubation is the best way to avoid such a complication.

If the patient has not been intubated and postoperative distention develops after an abdominal operation, in the absence of severe pain or shock, it usually is correct to assume that some degree of peritonitis exists, that plastic adhesions obstruct the bowel, that the chances of strangulation are low, and that intubation by the intestinal tube is desirable. This type of obstruction will be discussed in more detail in Chapter 25, and several important exceptions to this statement will be noted. If the tube passes well down the intestine, deflation usually occurs.

(*e*) *To treat mechanical obstruction exclusive of early postoperative obstruction*—(1) *Obstruction in small intestine.* It is the writer's belief that intubation is designed to aid and not to substitute for surgical relief of obstruction. Two reasons support this contention. In the first place, as emphasized in the discussion above, the clinical differentiation of simple and strangulating obstruction is very difficult. Secondly, even if strangulation can be excluded on clinical grounds and intestinal function returns to normal after intubation, the chances of recurrent obstruction are high. Enough patients treated in this fashion have returned later, seriously ill or even moribund, so that we are convinced in the Massachusetts General Hospital that unless the obstruction occurs early in the postoperative period, patients who are relieved of mechanical obstruction by intubation should be operated on before they leave the hospital.

Cantor is convinced of the wisdom of this decision. He has found that at least 30 per cent of patients relieved of mechanical small-bowel obstruction by intubation returned with a second bowel obstruction. He believes that, except in the unusual cases with extensive intestinal adhesions, the only function of the long intestinal decompression tube is to give the surgeon time to prepare the patient for surgery, make the operative field easier, or render the operation simpler.

On the other hand, Wangensteen advocated intubation as a safe method of therapy in 1932 and has continued to employ it in some cases of acute mechanical small-bowel obstruction. He found that a favorable response is most likely when the obstruction is partial, accompanying an inflammatory process, or occurring soon after a laparotomy.

If the surgeon uses intubation to facilitate surgery, he must select the type of tube that will be most satisfactory. On this point, too, there is no general agreement.

as, for example, strangulated hernia, will decrease the number of successes. Any figures, therefore, must be interpreted with caution. And again it must be emphasized that intubation cannot be expected to remove the cause of the distention in the great majority of cases.

In the Children's Hospital in Detroit, where treatment of obstruction is most commonly required for patients ill with the complications of appendicitis, Cantor noted that gastroduodenal drainage was effective in two-thirds of the cases; in the remainder a long tube was necessary to relieve the distention.

In 100 cases of intestinal intubation for small-bowel obstruction or distention, Harris found that relief without surgery was obtained in 41 cases.

Grafton Smith obtained clinical relief of obstruction by suction alone in 48 per cent of a total of 113 patients with various types of obstruction; the remainder required surgery. Suction was effective in 24 per cent of patients with primary small-bowel obstruction, 64 per cent of patients with mechanical postoperative obstruction, and 93 per cent of patients with postoperative paralytic ileus.

F. COMPLICATIONS OF INTUBATION

Many complications can follow the use of intubation. With adequate care most of them can be prevented. The most important are as follows.

1. Erroneous treatment.—The effects of erroneous treatment of strangulating obstruction by intubation rather than operation may be formidable and dangerous. For example, of 412 cases of obstruction due to adhesions, from the Charity Hospital, New Orleans, studied by Becker, in 52 tube decompression had been abused; 20 of the patients died, giving a mortality of 38.4 per cent, ascribable to this error in judgment. The error, of course, is much less frequent in institutions that have become more familiar with this method of treatment. For example, Wangensteen has stated that only one patient with gangrenous bowel was treated conservatively in a four-year period in his hospital.

2. Derangements of fluid and electrolyte balance.—These are certain to be severe unless adequate replacement therapy is carried out.

3. Local complications.—Pressure of the tube in nose, pharynx, and esophagus may cause complications. A sore throat is common. Some relief may be obtained from Aspergum or dibucaine (Nupercaine) lozenges. Pain in the ear is more serious and may presage an otitis media. The latter complication is particularly common in children. Sinusitis or abscess of the nasal septum may occur. Iglauer and Molt reported ulceration of the larynx in 10 patients, in eight of whom stenosis developed. If hoarseness occurs, suggesting laryngeal edema, the tube should be withdrawn. Rupture

may indicate the approximate site of obscure bleeding from the gastrointestinal tract. The long tube passed into the intestine may be used to introduce barium into a specific area for diagnostic X rays.

D. CONTRAINDICATIONS

At the Massachusetts General Hospital we believe that intubation as a primary method of treatment is contraindicated in strangulating obstruction, potentially strangulating lesions (intussusception, volvulus, congenital atresias, hernias, and so on), colonic obstruction with a competent ileocecal valve and, except for early postoperative obstruction, mechanical obstruction of the small intestine of less than 24 hours' duration. Suction treatment of ileus of any type must be succeeded by immediate operation when the clinical picture changes, suggesting the onset of strangulation, or when intubation has been unsuccessful after an adequate trial and has failed to relieve the obstruction.

E. EFFECTIVENESS OF INTUBATION

The effectiveness of intubation is difficult to measure because there are so many variable factors as well as criteria that may be set up to determine success or failure. Data are available to answer a few specific questions.

1. HOW FREQUENTLY DOES INTESTINAL TUBE ACTUALLY PASS INTO SMALL INTESTINE? While some authorities have considered passage of a tube into the second portion of the duodenum as a successful intubation, it seems better to use the stricter criterion of passage into the upper jejunum, since the ligament of Treitz often furnishes a formidable barrier to descent of the tube. The chief variables are the type of tube used and the skill and experience of the intubator. From the Presbyterian Hospital in New York City, Beverly Smith analyzed 1,000 cases of intubation in which the Miller-Abbott tube was used. The tube failed to pass the pylorus in 221 cases. It required one to five hours to enter the duodenum in 186 cases, six to 11 hours in 63, and 12 to 23 hours in 220. No data are available to indicate how many times the tube actually reached the upper jejunum.

The best recorded results have been obtained by Grafton Smith. Using his special tube in a series of 180 cases, he succeeded in passing it beyond the pylorus in 90 per cent in an average time of 11 minutes. In 64 per cent of the cases the tube was placed in the upper jejunum at the time of the original attempt at intubation.

2. HOW FREQUENTLY DOES INTUBATION RELIEVE ILEUS? This figure, also, will vary significantly, depending upon the selection of cases included. Thus, a high percentage of early postoperative obstructions will increase the successful results, while a high percentage of unrelenting obstructions,

7. Rupture of mercury-filled balloon.—Usually the mercury remains in the intestinal tract and no harm results. On the other hand, it may gravitate into the appendix, as reported by Crikelair and Hiratzka. In their case the appendix became inflamed and ruptured. A mercury granuloma appeared. Fistula formation may occur; in one case reported by McKittrick mercury appeared in a fresh herniorrhaphy incision.

8. Vomiting.—In the presence of a long tube, vomiting is common, since the stomach and duodenum may fill with fluid that is not passed far enough down the intestine to be aspirated by a deeply placed intestinal tube. This complication is treated best by the insertion of a Levin tube in the other nostril. An alternative method, suggested by Cantor, is to cut an additional hole in the long tube just outside the nares and push the additional length of tubing into the stomach.

9. Intestinal obstruction due to balloon.—Inadvertent irrigation or injections into the balloon of the Miller-Abbott tube may distend it and prevent deflation, producing a type of obturation obstruction. A second type of obturation is produced when the balloon initiates an intussusception.

of esophageal varices has occurred even with Levin tubes. A known esophagitis may be aggravated by any tube and result in a permanent stenosis. It is possible that this sequence may occur in the normal esophagus if the tube is left in position for several days.

4. Perforation.—Perforation has been observed in duodenum, stomach, and intestine. The use of a stylet in untrained hands is dangerous. If a tube advances to an obstructing point and stays there for several days, ulceration of the intestine is likely to occur, with perforation. Hence, if suction is to be continued and X ray examination shows the head of the tube in the same position on successive days, the tube must be partially withdrawn.

5. Knot formation.—This may occur with any type of tube, either in the stomach or in the dilated intestine. With a tight knot, aspiration ceases distal to the knot. With the Miller-Abbott tube, the knot may be so tight that the balloon cannot be deflated. Tubes with knots are withdrawn, if possible, into the pharynx, pulled out through the mouth to allow the knot to be cut off, and then removed through the nose.

6. Inability to withdraw balloon-tipped tube.—If balloons are tied tightly, they will fill with gas from the intestinal tract. Usually this makes no difference with a Miller-Abbott tube, since gas escapes readily through the inflating tube. With Cantor or Harris tubes, care must be taken to avoid too tight a knot on the tie that holds the balloon to the tube.

The collection of gas within the balloon is an interesting phenomenon. The permeability of natural and synthetic rubber varies with each specific gas. Permeability of any gas through a rubber membrane is independent of the pressure of any other gas on the other side of the membrane, though the thicker the rubber, the less the permeability. Carbon dioxide, hydrogen sulfide, and nitrogen are the gases most likely to diffuse into the balloon. Of these, nitrogen diffuses most slowly, so that if the intestinal gas contains a high percentage of nitrogen that diffuses into the balloon, it will be decompressed very slowly.

If a balloon becomes filled with gas and cannot be withdrawn, operation is necessary. The balloon is deflated by a fine needle passed through the wall of the intestine.

The balloon-tipped tube sometimes cannot be withdrawn for other reasons. If the bag passes the ileocecal valve, it will usually be necessary to cut the tube off at the nose and let it pass by rectum. Intussusception of the intestine may occur from the balloon, preventing withdrawal. In rare instances the balloon cannot be withdrawn, and if, after cutting, it fails to pass by rectum, laparotomy is necessary. The tube is withdrawn by enterotomy and the adhesions that prevented passage cut.

entire intracellular fluid, while only small amounts of these three are present in extracellular fluid. Chlorides and bicarbonate ions, which form most of the anions in the extracellular fluid, are found only in traces in the intracellular fluid.

A good deal of confusion has arisen in the past because of various methods of measurement of each constituent of body fluids. Gradually it has become

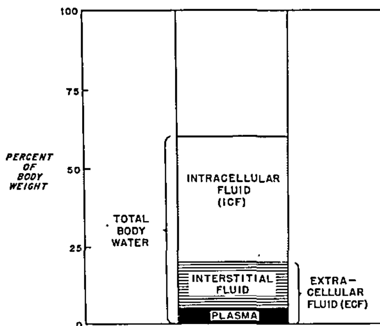


Fig. 43.—Distribution of body water into its various compartments, with approximation of amount of water in each.

the custom to express the weight of each substance in milliequivalents rather than to specify actual weights in grams. An equivalent weight of an element is that amount which combines with 1 Gm. of hydrogen. Thus, since 1 mol of sodium weighs 23 Gm., 1 mEq. equals 0.023 mg. One mol of calcium weighs 40 Gm. but is bivalent, so 1 mEq. equals 0.020 mg.

B. VARIATIONS ENCOUNTERED IN DISEASE

The problem of fluid and electrolyte replacement would be easy if it were possible to identify the effects of a diminution or an excess of any one component. However, it is difficult to disassociate combined effects, particularly when water and salt are concerned. Furthermore, symptoms of abnormalities of one electrolyte may be closely similar to those of another, making identification difficult. In general, it may be said that the effects of

9

Replacement Therapy

WATER AND ELECTROLYTE BALANCES and plasma and blood volume all demonstrate abnormalities in any patient with intestinal obstruction. These changes are not serious in the early hours, but as time passes after onset of simple obstruction, or if strangulation occurs, they alone may lead to death. A consideration of replacement therapy is particularly important for the surgeon who treats intestinal obstruction. Consequently, the fundamental facts of body fluids will be summarized, the effects produced by intestinal obstruction described, and the methods of treatment outlined.

A. COMPOSITION OF BODY FLUIDS

Fifty to seventy per cent of the weight of the human body is due to water. Body water is divided into several compartments (Fig. 43). The major portion is intracellular (35 to 50 per cent), and the lesser part is extracellular (15 to 20 per cent.) The extracellular fluid is composed of interstitial fluid (15 per cent of the body weight) and plasma (5 per cent). Sharp differentiation of these three types of fluid is necessary, since their composition varies remarkably.

It is only natural that attention should have been focused early on the constituents of blood plasma, since it was easily available for analysis. Reference to Figure 44, which shows the composition of these various fluids as they have been described by Gamble and co-workers, will demonstrate that sodium chloride and bicarbonate ions are by far the commonest in the extracellular fluid. Yet, from the point of view of the intimate body economy, the components of the intracellular fluids are much more significant. Here, potassium and magnesium are the important cations; while sodium may occur in certain tissues, such as muscle, the amount is relatively small. Of the anions, protein, sulfate, and phosphate comprise nearly the

entire intracellular fluid, while only small amounts of these three are present in extracellular fluid. Chlorides and bicarbonate ions, which form most of the anions in the extracellular fluid, are found only in traces in the intracellular fluid.

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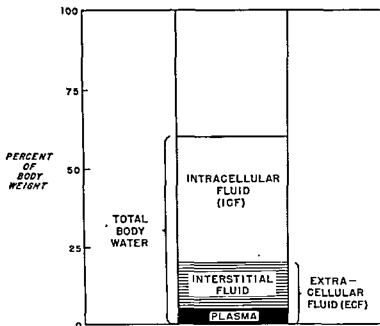


Fig. 43.—Distribution of body water into its various compartments, with approximation of amount of water in each.

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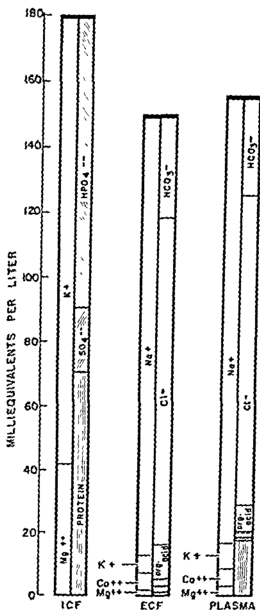


Fig. 44.—Composition of intracellular fluid, extracellular fluid, and plasma. (Adapted from Gamble and Moyer.)

a deficit or oversupply of blood are well understood, as are those of calcium. The behavior of potassium, sodium, water, chloride, and bicarbonate are less clear, while that of magnesium remains a mystery. The most important metabolic effects of each of these substances will be considered next.

1. Blood.—Blood loss in intestinal obstruction may arise from actual hemorrhage into the lumen or wall of the bowel, into the mesentery of the gut, or into the peritoneal cavity, whenever strangulation obstruction is present. The loss may be unexpectedly large. Gendel and Fine have shown that 28 per cent of the total circulating blood volume may be lost in strangulating obstructions produced in experimental animals. Ya, Perry, and Thein found that dogs with strangulated loops of small intestine comprising 8 to 12 per cent of the total length had 30 to 40 per cent of their entire red cell volume in the loop and peritoneal cavity at death; when 33 to 40 per cent of the small bowel was strangulated, up to 64 per cent of the total red cell mass was lost into the loop. In addition to actual blood loss, there may be extensive pooling of blood in mesenteric capillaries whether the obstruction is simple or strangulating. If an operative procedure is carried out, further loss may be anticipated. It is obvious that provision for transfusions should be made before any operation for obstruction.

As a general rule, blood volume should be brought up to normal before any serious operation. This is sometimes possible even though a relatively short period can be devoted to preparation. Cachectic patients, especially those with cancer, are particularly prone to the low blood pressure and collapsed veins that Clark, Nelson, Lyons, Mayerson, and DeCamp have dignified by the term "chronic shock." At the time of operation, if blood loss is 500 cc. or more, the blood should be replaced quantitatively. It must also be noted that operative trauma, especially in abdominal surgery, will lead to extravasation about the operating field and pooling of blood in the mesenteric capillaries. Thus, functionally the body is deprived of more blood than can be measured in discarded sponges and drapes. Any error in replacement therapy, therefore, should be on the generous side.

Failure to replace this blood will lead to all of the well-known features of oligemic shock. This type of shock should not be treated by intravenous administration of saline except as a temporary emergency measure while one is awaiting whole blood. If blood is unavailable, a plasma expander, such as dextran, is best.

Most errors of blood replacement therapy are due to the use of too little blood, but in some instances there is overtransfusion. This hypervolemia is manifested by a rise in blood pressure, falling pulse pressure, refractory cyanosis as blood pools in the lungs, and death. The patient actually dies of a fluid embolus.

Plasma.—The plasma deficit is constant and may be severe. In the dog, Gendel and Fine found it to be 48 per cent of the total plasma volume after four hours of strangulating obstruction, and this loss was sufficient to cause death. Edema fluid in burns in man has been shown by Cope and others to consist of approximately 50 per cent plasma and 50 per cent extracellular fluid. If the edema fluid in the wall of obstructed bowel is similar, the loss may be considered to be large. The peritoneal fluid that forms after obstruction may contain as much as 6 per cent protein, a level only slightly below the normal serum protein.

The administration of plasma until recently carried the hazards of homologous serum hepatitis. Since Allen showed that the virus may be destroyed by allowing plasma to stand for six months at room temperature, plasma has become more popular. Insofar as intestinal obstruction is concerned, its use is indicated frequently. It is particularly valuable in patients with long-standing obstruction who have a high hematocrit level, particularly when the blood pressure is low and pulse rapid; 250 to 500 cc. or even more may be given preoperatively, together with water and electrolytes.

2. WATER.—The problems of water replacement are much more difficult. While blood volume and red cell mass are easy to measure, there is no simple way to measure either total body water, intracellular water, or extracellular water. Water requirements per day are well known but vary greatly, depending upon the types of food eaten and the body and environmental temperature. Body water is gained from three sources—water consumed as such, water from so-called solid foods, and water that is formed by metabolism from certain substances, such as glycogen. Water is lost in the urine, in the feces, through the lungs as water vapor, and from the skin as sweat. Loss through the lungs and skin is known as "insensible loss" and is measured accurately by methods too complicated to be used clinically. Yet these losses must be estimated daily by the surgeon when he plans the patient's fluid supplies.

When an elective operation is carried out on a patient in good condition, he should receive blood replacement and enough water as 5 per cent dextrose in water to counterbalance his insensible loss. This loss will be less than 200 cc. per hour in a cool operating room, but it may be as high as 600 cc. per hour if the operating theater is hot. Postoperatively, more water will be required to cover the insensible loss and urine for the remainder of the 24 hours. Since the insensible loss for 24 hours is 750 to 1,000 cc. and urine output is maintained at about the same level, about 1,500 cc. of 5 per cent dextrose in water is required on the day of operation.

On the following days the water requirement may be complicated by loss

of water from a Levin or other gastric or intestinal drainage tube. Meanwhile, the insensible loss may become much higher than the basal rate of 750 cc. if the patient is sweating either from fever or from a high environmental temperature. Sweating begins at 78 F. when the humidity is 60 per cent, and if the mean room temperature is five degrees above that level, water loss is increased by about 1,000 cc. daily.

When the patient has intestinal obstruction, the water balance has deteriorated seriously even before operation. It may be estimated, according to Moyer, that water corresponding to 6 per cent of the body weight has been lost when the patient appears moderately dehydrated and to 10 per cent if the dehydration is severe. This defect is due to decreased intake, to loss by vomiting, and to excretion into the dilated bowel. It is impossible to document this loss accurately, and the surgeon must estimate roughly the amount necessary for replacement. Usually an operation is urgent; consequently, if complete replacement were desired, a large amount of fluid would have to be given in a short period. This is undesirable, since pulmonary edema may occur. It is better to attempt only a partial correction before laparotomy and continue rectification of the deficit after operation.

When water requirements are not accurately met, either the extracellular fluid will diminish in amount, producing dehydration, or it will increase in volume, producing pulmonary edema or water intoxication.

(*a*) *Dehydration.*—Several features are important in diagnosing dehydration. The history helps quantitate the amount of the water deficit. The tongue is dry and wrinkled, the skin lies in folds and has lost its turgor, the blood pressure is low and the veins collapsed, and the extremities are cold and blue when the loss is severe.

Physiologically, there are two entities encountered in patients with dehydration. Commonly, water and electrolytes have been lost in approximately equivalent amounts. Measurements of the sodium, potassium, and chloride in the plasma are then essentially normal. However, the hematocrit level and serum protein content tend to be above normal. This is the situation in early acute obstruction. The other entity is encountered much more rarely. If a person stops eating and drinking, particularly in a hot temperature or when he has fever, more water is lost than electrolytes. The tongue becomes dry, swollen, and red and the face flushed; the urine output drops and the concentration decreases. The same physiologic state is produced when the water level of the extracellular fluid remains constant while the body is flooded with sodium chloride. In either case plasma determinations will show that sodium and chloride levels are well above normal.

Therapy in the two groups of patients obviously must be quite different. In the first, electrolytes must be restored, together with water, but in the

Plasma.—The plasma deficit is constant and may be severe. In the dog, Gendel and Fine found it to be 48 per cent of the total plasma volume after four hours of strangulating obstruction, and this loss was sufficient to cause death. Edema fluid in burns in man has been shown by Cope and others to consist of approximately 50 per cent plasma and 50 per cent extracellular fluid. If the edema fluid in the wall of obstructed bowel is similar, the loss may be considered to be large. The peritoneal fluid that forms after obstruction may contain as much as 6 per cent protein, a level only slightly below the normal serum protein.

The administration of plasma until recently carried the hazards of homologous serum hepatitis. Since Allen showed that the virus may be destroyed by allowing plasma to stand for six months at room temperature, plasma has become more popular. Insofar as intestinal obstruction is concerned, its use is indicated frequently. It is particularly valuable in patients with long-standing obstruction who have a high hematocrit level, particularly when the blood pressure is low and pulse rapid; 250 to 500 cc. or even more may be given preoperatively, together with water and electrolytes.

2. WATER.—The problems of water replacement are much more difficult. While blood volume and red cell mass are easy to measure, there is no simple way to measure either total body water, intracellular water, or extracellular water. Water requirements per day are well known but vary greatly, depending upon the types of food eaten and the body and environmental temperature. Body water is gained from three sources—water consumed as such, water from so-called solid foods, and water that is formed by metabolism from certain substances, such as glycogen. Water is lost in the urine, in the feces, through the lungs as water vapor, and from the skin as sweat. Loss through the lungs and skin is known as "insensible loss" and is measured accurately by methods too complicated to be used clinically. Yet these losses must be estimated daily by the surgeon when he plans the patient's fluid supplies.

When an elective operation is carried out on a patient in good condition, he should receive blood replacement and enough water as 5 per cent dextrose in water to counterbalance his insensible loss. This loss will be less than 200 cc. per hour in a cool operating room, but it may be as high as 600 cc. per hour if the operating theater is hot. Postoperatively, more water will be required to cover the insensible loss and urine for the remainder of the 24 hours. Since the insensible loss for 24 hours is 750 to 1,000 cc. and urine output is maintained at about the same level, about 1,500 cc. of 5 per cent dextrose in water is required on the day of operation.

On the following days the water requirement may be complicated by loss

of water from a Levin or other gastric or intestinal drainage tube. Meanwhile, the insensible loss may become much higher than the basal rate of 750 cc. if the patient is sweating either from fever or from a high environmental temperature. Sweating begins at 78 F. when the humidity is 60 per cent, and if the mean room temperature is five degrees above that level, water loss is increased by about 1,000 cc. daily.

When the patient has intestinal obstruction, the water balance has deteriorated seriously even before operation. It may be estimated, according to Moyer, that water corresponding to 6 per cent of the body weight has been lost when the patient appears moderately dehydrated and to 10 per cent if the dehydration is severe. This defect is due to decreased intake, to loss by vomiting, and to excretion into the dilated bowel. It is impossible to document this loss accurately, and the surgeon must estimate roughly the amount necessary for replacement. Usually an operation is urgent; consequently, if complete replacement were desired, a large amount of fluid would have to be given in a short period. This is undesirable, since pulmonary edema may occur. It is better to attempt only a partial correction before laparotomy and continue rectification of the deficit after operation.

When water requirements are not accurately met, either the extracellular fluid will diminish in amount, producing dehydration, or it will increase in volume, producing pulmonary edema or water intoxication.

(*a*) *Dehydration.*—Several features are important in diagnosing dehydration. The history helps quantitate the amount of the water deficit. The tongue is dry and wrinkled, the skin lies in folds and has lost its turgor, the blood pressure is low and the veins collapsed, and the extremities are cold and blue when the loss is severe.

Physiologically, there are two entities encountered in patients with dehydration. Commonly, water and electrolytes have been lost in approximately equivalent amounts. Measurements of the sodium, potassium, and chloride in the plasma are then essentially normal. However, the hematocrit level and serum protein content tend to be above normal. This is the situation in early acute obstruction. The other entity is encountered much more rarely. If a person stops eating and drinking, particularly in a hot temperature or when he has fever, more water is lost than electrolytes. The tongue becomes dry, swollen, and red and the face flushed, the urine output drops and the concentration decreases. The same physiologic state is produced when the water level of the extracellular fluid remains constant while the body is flooded with sodium chloride. In either case plasma determinations will show that sodium and chloride levels are well above normal.

Therapy in the two groups of patients obviously must be quite different. In the first, electrolytes must be restored, together with water, but in the

second, water alone is indicated and it must be given cautiously because of diminished renal reserve.

(*b*) *Overhydration.*—Two groups are also found among patients who have been overhydrated. In the first, electrolytes have increased proportionately with water. There is evidence of edema (swollen eyelids, pulmonary rales, pitting edema of legs or sacrum). The hematocrit level and plasma protein content are below normal, but electrolyte levels are normal.

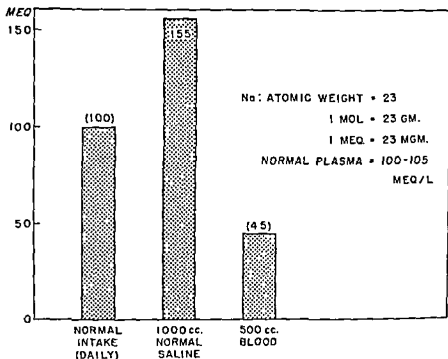


Fig. 45.—Sodium intake.

This is the typical picture when a postoperative patient has been flooded with normal saline solution for several days. If renal function is normal, the situation can be corrected easily by the administration of blood and potassium.

Patients of the second group are not seen often by the surgeon. They have true water intoxication, which occurs particularly in hot weather, when unrestricted amounts of water are taken without any electrolyte replacement. Headache, nausea, vomiting, and cramps may be followed by stupor. Chloride and sodium are very low, both in the plasma and in the urine. This true water intoxication is cured rapidly by electrolyte administration.

3. Sodium.—Some indication of the importance of sodium has already

been given, since the behavior of water is intimately related to it. Features peculiar to this electrolyte will now be considered. Large reserves of it are stored in the body, possibly in the bone, as Moore has suggested. At any rate, in the ordinary surgical patient, deficits are encountered rarely, while overloading of the patient with sodium by the surgeon is all too common.

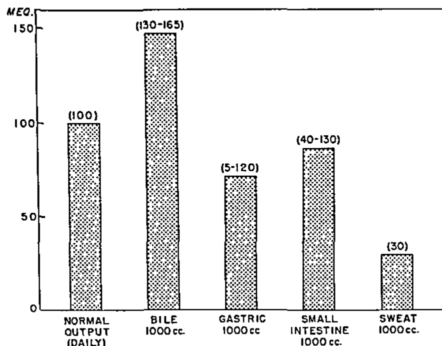


Fig. 46.—Approximate daily losses of sodium. Output in sweat varies greatly with temperature. (*See* discussion in text.)

TABLE 5.—AVERAGE COMPOSITION OF BODY FLUIDS (IN MILLIEQUIVALENTS PER LITER)

	Na	K	Cl	HCO_3
Gastric aspirate	25	12	150	0
Intestinal juice	140	10	105	25
Bile	140	10	100	30
Pancreatic juice	140	10	75	75

Normally, 100 mEq. of sodium is ingested daily and the same amount excreted through the kidneys. After surgery, sodium is conserved for several days, so that loss in the urine is not noted until about the fifth postoperative day. During the early period there is ordinarily no need to administer sodium. Hence most surgical patients will not require any of this electrolyte in the postoperative course (Figs. 45, 46).

However, serious deficits of sodium occur in certain instances. This deficit may be especially serious if the patient's electrolyte balance has been precarious before operation and his reserves depleted. It is most likely to develop after protracted vomiting from intestinal obstruction or after diarrhea or jaundice. Continuing extrarenal losses after operation increase the need for sodium. Bile contains 130 to 165 mEq., gastric juice 5 to 120 mEq., small-intestinal contents 40 to 130 mEq., and sweat about 30 mEq. per liter. Consequently, a sweating patient with various tubes draining body fluids may deplete himself of sodium rapidly (Table 5).

There is no question but that all extrarenal losses of sodium must be made up after the fifth day following any elective operation, as Moore has demonstrated. However, when the patient has intestinal obstruction, it is preferable to correct the deficit as well as to replace the extrarenal loss from the outset, since, in several instances, a low-sodium syndrome has been encountered two to three days after surgery.

Another way in which sodium loss may occur is via the diseased kidney. A salt-losing nephritis or adrenal exhaustion will lead to depletion of the sodium in the extracellular fluid. Other abnormal states are encountered not infrequently in which the sodium level is either too low or too high; for example, it may be low in cirrhosis of the liver.

(*a*) *Low-salt syndrome.*—The low-salt syndrome must be suspected in depleted patients, especially in those who have a history of vomiting, diarrhea, or long-continued fistulous drainage from the gastrointestinal tract and in those who have jaundice. It is manifested by weakness, listlessness, poor function of the gastrointestinal tract, acidosis or alkalosis, and later by signs of peripheral vascular collapse. The patient may experience a sudden collapse and after the injection of normal saline solution a recovery that is just as dramatic.

When this syndrome is suspected, the plasma sodium, potassium, carbon dioxide, chloride, and protein must be checked. The carbon dioxide level usually is high, indicative of alkalosis, while the other levels are low. The treatment consists of administration of sodium as chloride, as bicarbonate, or as lactate. Nearly always, and particularly as an emergency, the rapid injection of normal saline solution is the keystone of treatment. Some authorities, such as Moyer, prefer the administration of hypertonic salt solution (3 per cent sodium chloride) first and later correction of the electrolyte concentration by water. However, such hypertonic solutions are prone to produce a chemical phlebitis and to induce obscure changes in the blood-clotting mechanism, and it is our belief at the Massachusetts General Hospital that they should be avoided whenever possible. They usually

can be avoided, since the extracellular fluid tends to be below its normal volume when the salt level is low.

Functional adrenal failure may be implicated in any case of the low-sodium syndrome. The renal loss of chloride is unsuspected unless routine checks of the chloride level of the urine are done. The urine output is large, and the sodium concentration in it is high. The patient is seriously ill and hypotensive. The plasma sodium is low; the eosinophil count is

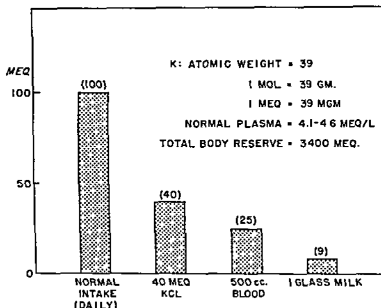


Fig. 47.—Potassium intake, with comparative amount of potassium in various substances.

variable, but may be low. In addition to the treatment noted above, cortisone must be administered.

(*b*) *Overadministration of sodium.*—Overadministration of sodium due to overzealous surgical care is not uncommon. Edema and hypoproteinemia are produced. Meanwhile, sodium shifts across the cell membrane, displacing potassium from the cell, producing effects that will be considered later. The treatment consists of the omission of saline, while potassium and water are given to wash out the salt.

4. Potassium.—The normal daily intake of potassium is 100 mEq. This is excreted nearly entirely in the urine. The body reserves are relatively small, amounting to only 3,400 mEq., so that rapid potassium depletion may occur after operation. On the other hand, since replacement is easy,

there should be no reason for potassium depletion to occur. After operation, 20 to 50 mEq. is lost daily in the urine. This loss will not cause any harm after simple procedures, but potassium must be replaced after the third day following serious operations. It is essential that a good urinary output be maintained when potassium is being administered, or toxic levels may be induced (Figs. 47, 48).

Administration of potassium is relatively easy. For intravenous use, a 40 mEq. ampule of potassium chloride is mixed with a liter of 5 per cent dex-

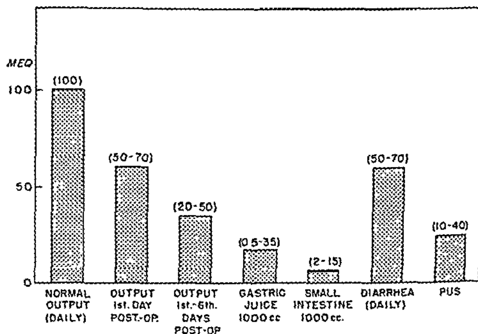


Fig. 48.—Potassium output, adapted from Moore's data, with approximate losses by various routes.

trose in water. Five hundred cubic centimeters of blood contains 20 mg. of potassium. Oral intake will be the usual source of supply as soon as the gastrointestinal tract is functioning.

Potassium is lost in the urine and by extrarenal routes. Gastric juice contains 0.5 to 30 mEq. per liter, and the small-intestinal content is 2 to 15 mEq. Diarrhea may account for a loss of 15 to 70 mEq. daily and purulent discharge for 10 to 40 mg.

(*a*) *Potassium deficit.*—It is clear that potassium deficit is the commonest abnormality of this ion, though the small amount in the upper-intestinal contents means that this deficit is not encountered with acute obstruction and a short history. Absolute proof of a deficit can be made only by actual

tissue analysis, for potassium in the plasma is merely en route to the cell for absorption or to the kidney for excretion. The syndrome should be suspected in cases of chronic high-intestinal or pyloric obstruction, in exacerbations of acute ulcerative colitis, and in postoperative patients who have had an excess of salt. It is manifested by muscular weakness, a soft pulse, anorexia, diminished reflexes, disorientation, silent ileus, and meteorism, and often by fever. Alkalosis with tetany may be encountered. The electrocardiogram may show low T waves and a depression of the ST segment. The plasma potassium level may be normal (4.1 to 4.6 mg.) but usually is somewhat low.

The potassium loss in experimental intestinal obstruction has been studied by Schilling, McCoord, and Clausen. The acute loss of potassium in their experiments did not exceed 4 per cent of the body total, as compared with the acute loss of sodium which approximated 25 per cent of the body total in certain instances. They concluded that potassium loss was not toxic per se in their acute experiments.

The syndrome of "hypokaliemic alkalosis" is a variant of potassium depletion. The typical clinical course is that of a patient who had been vomiting for weeks from an obstructed ulcer. The physiologic factors involved have been described by Moore. The obstruction produces intracellular potassium depletion. Complete obstruction leads to a metabolic alkalosis. The patient is treated with normal saline, which causes salt retention and a sodium shift into the intracellular fluid. He is then operated on, and the stress effect is noted. Clinically, the patient appears weak, apathetic, and disoriented, with a silent abdomen. The laboratory findings show a low chloride, normal sodium, high carbon dioxide, and high nonprotein nitrogen, and the potassium may fall to 2.5 mEq. per liter. The electrocardiogram may show evidence of lack of potassium. In treatment, potassium chloride, blood, and water are essential. Sodium chloride will make the patient worse.

(*b*) *Potassium intoxication.*—This may be expected when there has been extensive tissue damage, as by trauma, burns, or pancreatitis, in the presence of peripheral circulatory failure that produces oliguria or anuria. It also is easily produced by the overadministration of potassium to a patient with deficient kidney function. The symptoms are not distinctive, and consist only of nausea, vomiting, or diarrhea. Electrocardiographic changes appear early. At first the T waves are high and the ST segment depressed; later the T waves disappear, and finally heart block with diastolic cardiac arrest occurs. Whenever kidney function is poor, the plasma potassium must be checked before potassium is given. This level is a more sensitive indicator than the electrocardiogram.

Hyperpotassemia is a problem when renal function is diminished. In its

presence potassium cannot be washed out with excess fluid. The artificial kidney is an effective means of treatment. Cation exchange resins, such as polyamine-methylene resin (Resinat), are more practical. Since they will remove cations indiscriminately, supplemental injection of calcium, which is always removed in preference to others, and of salt will be necessary.

Hyperpotassemia was noted by Scudder, Zwemer, and Whipple in many cases of intestinal obstruction, and they believed that an elevated potassium level was an important cause of death in obstruction. Their findings have not been confirmed; actually, with obstruction, loss of potassium leads to hypopotassemia.

5. CALCIUM.—Only brief mention need be made of abnormalities of the calcium ion. An acute deficiency may be produced by parathyroid damage, acute pancreatitis, general peritonitis, intestinal fistulas, or other lesions that produce massive tissue destruction, such as burns. Queerly enough, it has been noted in strangulating small-intestinal obstruction. Massive repeated citrated-blood transfusions may also precipitate an acute deficiency. The symptoms of numbness, tingling, cramps, carpopedal spasm, and tetany indicate the diagnosis, which can be confirmed by the finding of a low serum calcium. Ten per cent calcium gluconate or chloride is given intravenously for treatment, to be followed by calcium lactate by mouth. Hypercalcemia occurs only rarely and nearly always in the presence of hyperparathyroidism or renal disease.

6. MAGNESIUM.—Magnesium must be a very important element, since it is present in a concentration of over 40 mEq. per liter in the intracellular fluid. However, little is known about its metabolism or the effects of depletion or oversupply. Haynes, Crawford, and De Bakey found that magnesium behaves much like sodium in the postoperative patient. There appears to be a retention after surgery, and excretion is controlled by the adrenal cortex.

7. SUMMARY OF ABNORMALITIES ENCOUNTERED IN OBSTRUCTION.—Though actual blood loss is encountered only in strangulating obstruction, the circulating blood volume may be reduced considerably, even in simple obstruction, by distention and pooling in the mesentery. Plasma loss is greater and is important in all types of obstruction. A water deficit occurs regularly and may be as much as 10 per cent of the body weight. Electrolyte losses depend upon the location of the obstruction. There are essentially no derangements when obstruction is in the colon. They are most serious in high small-bowel obstruction; with pyloric obstruction, unless the patient has achlorhydria, chloride loss is far greater than sodium loss and alkalosis results. With jejunal obstruction, since the electrolyte composition of the fluid loss is similar to that of the blood plasma, the serum carbon dioxide

level remains near normal. Sodium and chloride losses are high and the potassium deficit less significant. Owing to the diminished urine volume, the nonprotein nitrogen rises as obstruction progresses.

C. CALCULATION OF FLUID AND ELECTROLYTE REQUIREMENTS

As a practical guide, the selection of the fluid and electrolyte intake for patients with obstruction may be summarized as follows: If the patient has previously been in good health and has early acute simple small-bowel obstruction or acute colon obstruction, no particular preoperative correction of blood, plasma, water, or electrolytes is required; 1,500 cc. of 5 per cent dextrose in water will be sufficient. Patients with strangulating obstruction often require preoperative blood or plasma transfusions. Time does not permit other than partial correction of electrolyte imbalances; this must be carried out in the postoperative period.

Patients with late simple obstruction, in whom operation is postponed in favor of a period of tube decompression, should have a complete replacement program carried out if possible. A normal renal flow must be established and checked, preferably by an inlying catheter. The amount of water lost by dehydration must be estimated.

Electrolytes are lost concomitantly with water, so that replacement of salt and potassium will be necessary. Five per cent dextrose in normal saline solution is used, 2 per cent of the body weight being given for mild, and 6 per cent of the body weight for severe dehydration. At least 45 mEq. of potassium is administered daily providing kidney function is normal. If the patient is anemic he must be given transfusions. Plasma is superior to whole blood if the patient has a high hematocrit level and is not in shock. Results of therapy must be checked by daily chemical determinations.

Postoperative therapy.—After operation the daily requirements will be similar in all cases.

(1) *Blood:* only if required because of previous anemia or operative loss.

(2) *Water:* from

(*a*) urine output		1,000 cc.
(*b*) gastrointestinal tract drainage		0-3,000 cc.
(*c*) diarrhea		0-1,000 cc.
(*d*) wound drainage		0- 500 cc.
(*e*) water vapor } (*f*) sweat }		750-1,500 cc.
	Total	1,750-7,000 cc.

(3) *Sodium:* must be given to replace all extrarenal losses. It is usually not necessary to replace it before the third day unless there was an uncorrected preoperative deficit. Count all gastrointestinal tract and wound drainage as normal saline and sweat as 1/3 normal saline.

(4) *Potassium:* should be replaced from the date of operation, assuming renal output

is normal. To the extrarenal losses (0-80 mEq.) must be added the basal renal loss, (40 mEq.). This makes a total of 40-120 mEq. It must be given as potassium chloride mixed with dextrose in water.

To make the final formulation, first estimate the total amount of sodium required and give as 5 per cent dextrose in normal saline solution. Give the balance of water required as 5 per cent dextrose in water, to which potassium is added.

As a general rule, this means that after operation for early obstruction the patient will receive 2,000 cc. of 5 per cent dextrose in water, 1,000 cc of dextrose in normal saline solution, and 40 mEq. of potassium daily for two or three days. This routine is eliminated as soon as it is possible to administer fluids by mouth. It is perhaps unnecessary to reiterate one of the important requirements of intravenous administration; namely, that the solutions be sterile and inserted under sterile precautions. *These fluids should be given slowly*, at the rate of 40 to 50 drops per minute; rapid administration causes an increased loss through the kidneys and may actually produce dehydration. Furthermore, *too rapid infusion may lead to pulmonary edema, refractory cyanosis, and even death*. For the same reason it is better to give the intravenous solutions at intervals throughout the day rather than consecutively.

TABLE 6.—COMPOSITION OF INTRAVENOUS SOLUTIONS (ELECTROLYTE VALUES IN MILLIEQUIVALENTS PER LITER)*

	Na	K	Cl	Lactate	Phosphate	Caloric Value
5% dextrose in water	0	0	0			200
5% dextrose in saline	145	0	145			200
5% dextrose in water and 40 mEq. KCl	0	40	40			200
5% amigen in 5% glucose	42	2	0			200
5% dextrose and 7% alcohol	0	0	0			690
Multiple electrolytes in 5% dextrose in water	40	35		20	15	
Sodium chloride or lactate in 5% dextrose in water	90		70	20		
3% NaCl	513		513			

* These are the solutions available at the Massachusetts General Hospital.

As convalescence progresses, it is well to consider the addition of caloric

intake by the intravenous route, provided the gastrointestinal tract is not yet ready to receive food. Now, a protein hydrolysate (Amigen) is of value, though it is apparently not retained in the early postoperative periods. Alcohol furnishes an excellent means of intravenous alimentation.

The most useful intravenous solutions are summarized in Table 6. It will be noted that they include blood, water, salt, potassium, and protein hydrolysates (intravenous). The only anion that frequently needs replacement in surgical patients is the chloride ion. Phosphate and sulfates are available in special solutions. Chloride is best given as sodium chloride.

It is possible to replace either anions or cations alone when they are combined with an ion that is broken down and metabolized by the body. Sodium lactate furnishes a disposable anion, as does sodium bicarbonate. Ammonium chloride provides a disposable cation, but it is dangerous since it may produce ammonium intoxication.

10

Management of Obstruction in Infants

OBSTRUCTION IN THE NEONATAL PERIOD introduces many problems that are not encountered in an older age group. The *diagnosis* is sometimes clear on inspection, as with an imperforate anus, but in other instances it may not be evident. An infant normally may regurgitate a small amount of swallowed amniotic fluid during the first day of life; if such regurgitation should recur after gastric aspiration, the diagnosis of obstruction must be entertained. The important diseases to rule out because they may present a somewhat similar picture are, according to Koop, central nervous system lesions, genitourinary tract obstruction, and cardiorespiratory problems. The normal infant passes a wet meconium stool soon after birth. If none appears, rectal examination and irrigations are indicated; if meconium cannot be obtained thereby, the infant almost surely has obstruction.

When vomiting recurs or meconium does not appear, X ray pictures must be taken. The scout film may demonstrate dilated loops of small intestine or, with duodenal obstruction, a huge stomach and proximal duodenum. A swallow of barium rarely is necessary to confirm the diagnosis. A barium enema is valuable whenever the question of Hirschsprung's disease, malrotation, or atresia or stenosis of the colon arises.

The causes of obstruction will be listed here and described in later sections. *Pyloric* obstruction, due to congenital hypertrophic pyloric stenosis, has been reported as early as the fourth day of life, though it is rarely noted before the third week. Obstruction of the *colon* is uncommon except that due to imperforate anus or congenital megacolon. The small intestine, therefore, is the area commonly involved. The *duodenum* may be obstructed by bands, an annular pancreas, a congenital diaphragm, or atresia. Lesions of the *jejunum* and *ileum* include external hernia, volvulus of the midgut, meconium ileus, atresia, and stenosis. A *diaphragmatic hernia* can obstruct the esophagus, stomach, small intestine, or colon.

Operation preferably is done as soon as the diagnosis is made, though occasionally, in late cases, a few hours may be devoted to the restoration of fluids; a longer delay leads to fatigue and respiratory failure because of elevation of the diaphragm.

Meticulous care is essential in all cases, but particularly if surgery is done in the premature. Gross and Ferguson reported 31 survivors in a group of 60 premature infants with intestinal obstruction by attention to the following principles.

The infant must be kept in a warm constant temperature, isolated and watched, but handled as little as possible. Preoperatively vitamin K is given because of transient hypoprothrombinemia, which may appear three days after birth; a routine daily dose of 2.5 mg. is given subcutaneously. Routine administration of antibiotics is begun, to be continued postoperatively. Penicillin (30,000 units in 24 hours) and streptomycin, (10 mg. per pound per 24 hours) are preferred. Oxygen is often necessary. Sedatives are avoided. Atropine sulfate (0.065 mg.) is given subcutaneously an hour before operation. The anesthesia of choice is cyclopropane. Preparation must be made for blood transfusions during the operation; an indwelling plastic catheter should be placed in a vein preoperatively. Postoperatively, excessive parenteral administration of fluids is exceedingly dangerous; not more than 30 cc. per pound per day should be given for four or five days after surgery. Salt solutions are poorly tolerated, but blood, plasma, and albumin are important. A multiple electrolyte solution, containing relatively little salt, on the other hand, is probably superior to dextrose in water solution. Intermittent gastric aspiration is superior to constant gastric suction because of the danger of edema of the glottis. Oral feedings are begun as soon as possible, but usually a five-day interval is necessary.

Quinby has emphasized several important generalizations that distinguish the intestinal obstructions encountered in infancy and childhood from those seen in adults. They are:

1) Infants and children become dehydrated more rapidly, develop gangrene more rapidly after strangulation, and tolerate peritoneal insults less well than adults. Therefore, early operation, as soon as electrolytes have been corrected, is preferable to exhausting diagnosis.

2) Intestinal tube decompression is poorly tolerated. As an alternative method for the treatment of postoperative distention, the use of a polyvinyl catheter enterostomy seems to be the best solution.

3) Acute small intestinal obstruction due to adhesions appears to be much more common in infants and children who have had a previous laparotomy than in adults.

PART III: TYPES OF ACUTE OBSTRUCTION

The specific types of obstruction and their treatment will now be considered in more detail, the following discussion supplementing that of the fundamental aspects of therapy contained in Part II. From a practical point of view, many types of obstruction are so infrequent that they rarely need be considered preoperatively. But, while the surgeon must plan his surgical attack on the basis of the commonest probabilities, he must be prepared to deal with rare lesions when they are encountered. In this part of the book, therefore, each entity will be described according to an etiologic outline rather than according to frequency or importance, following the classification in Table 3 (p. 50).

11

Obstructions Due to Congenital Abnormalities

A. ATRESIA AND STENOSIS

1. Congenital Atresia

ATRESIA SIGNIFIES A COMPLETE ABSENCE of continuity of some portion of the intestine or colon. It is uncommon; Wangensteen estimates that it occurs about once in every 20,000 births. Unless surgical relief is obtained, death occurs within a few days.

Though several theories have been advanced, both atresia and stenosis usually are believed to be due to an arrest in development in the second or third month of fetal life. At this time the intestine is a solid cord, but it normally acquires a lumen soon afterward. Other associated congenital abnormalities are not uncommon. Mongolism was noted in seven out of 36 patients with atresia or stenosis in the series studied by Gross.

Pathology.—There are two types of atresia. In one there is continuity of the gut but complete obstruction due to an internal diaphragm. In the commoner type, the intestinal lumen ends blindly, and it is entirely separate from the lower segment or is connected to it by a thin cord. In order of frequency, the site of atresia is found in the ileum, duodenum, jejunum and colon. Multiple atresias are found in about 15 per cent of the cases.

The intestine rapidly becomes greatly dilated above the obstruction. Necrosis, perforation, and death follow rapidly. The tiny distal intestine remains only a few millimeters in diameter and stays empty.

The discontinuity of the intestinal tract prevents passage of meconium. Farber devised a test based on the absence of epithelial cells in the meconium that is diagnostic of atresia. Meconium is a mixture of vernix caseosa (swallowed desquamated epithelial cells from the infant's skin), bile pig-

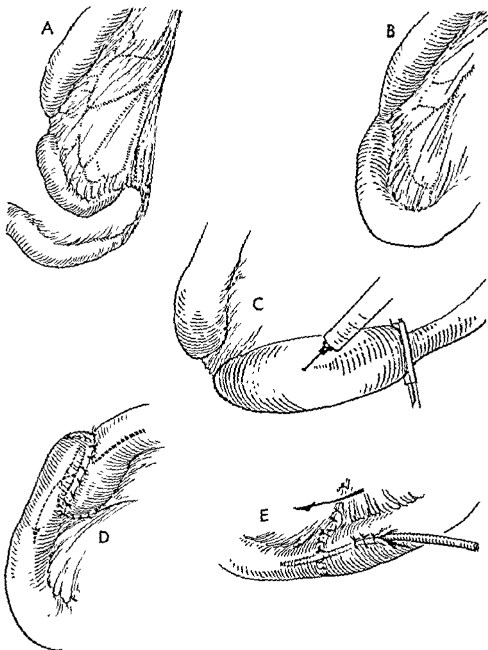


Fig. 49.—Congenital atresia and stenosis. A, multiple atresias. B, single stenosis. C, tiny distal segment may be dilated by injecting saline solution. D, side-to-side anastomosis may be only possible procedure. E, end-to-end anastomosis is preferred with enterostomy tube.

ment, bile salts, cholesterol, fat, stearic acid, sebaceous material from swallowed amniotic fluid, mucus, salts, pancreatic and gastric secretions, and enzymes. The epithelial cells are easily identified. A specimen from the center of the stool is smeared on a slide, covered with Sterling's gentian violet for



Fig. 50.—Atresia of ileum. Girl, aged 5 days, reportedly had a meconium stool within 48 hours of birth. She had no stools thereafter and showed signs of intestinal obstruction. Operation revealed ileal atresia.

a minute, washed in running water, and then decolorized with acid alcohol. Only the cornified epithelial cells retain dye. If none are observed the test is positive. Cells are present if obstruction is due to any other cause, such as stenosis or meconium ileus.

Diagnosis.—Symptoms appear on the first day of life. Vomiting is frequent and profuse. The vomitus as a rule contains bile, though in the unusual atresias, located above the level of the ampulla, it is absent. The stools tend to be small and greenish rather than to be of normal meconium, but

Farber's test is quite important, since it provides accurate differentiation.

The X ray film will show marked distention of stomach and intestine above the point of obstruction. Administration of barium is of great advantage in deciding upon the site of block. A thin barium enema will demonstrate any atresia present, either alone or in addition to another higher in the gut. A swallow of thin barium is valuable with high obstruction (Fig. 50).

TREATMENT.—Though operation has carried a high mortality in the past, present statistics show much better records. Glover ascribes failures to (1) metabolic depletion of the infant due to delayed diagnosis; (2) inadequate supportive therapy; (3) technical failure to restore complete continuity of the intestinal tract; (4) failure to protect the anastomosis by a proximal enterostomy; (5) too deep and prolonged anesthesia.

The main technical problem consists in the anastomosis of a distended proximal segment to the tiny, collapsed distal bowel. To aid in the procedure, the upper intestine should be collapsed by aspiration and the distal segment inflated by salt solution (Fig. 49).

The operative procedures must vary with the location of the atresia. When it is in the duodenum, lateral duodenojejunostomy is the method of choice. In the jejunum, an anastomosis is always necessary. While an end-to-end union functionally is best, a very tiny distal segment may require a side-to-side anastomosis. Two rows of sutures are preferable (0000 catgut and 00000 silk), though a single row of silk may be all that can be used. In the distal ileum, most surgeons prefer primary anastomosis, though Gross still believes an exteriorization operation based on the Mikulicz' type is best. Benson prefers primary anastomosis and has reported on 14 patients, of whom 10 survived. He found that resection of the bulbous, hypertrophied blind pouch in atresia of the jejunum and ileum is necessary to obtain a functioning anastomosis. Gerrish also uses a primary end-to-end anastomosis and adds a proximal enterostomy tubing made of polyvinyl to secure decompression during the period of healing.

In atresia of the colon, Wilson, Nelson, and Harshbarger note that there have been only seven operative survivals; they prefer primary anastomosis.

2. CONGENITAL STENOSIS

Stenoses of the intestine and colon differ from the atresias in that lumens are present, though they usually are not large enough to function satisfactorily. The degree of stenosis is variable, and the severer the stenosis, the earlier obstructive symptoms appear. In rare instances, obstruction from this cause is not manifest until adult life.

PATHOLOGY.—The duodenum is by far the commonest site of stenosis.

Stenosis is also common in the ileum, but it is rare in the jejunum and colon. Multiple stenoses are rare.

SIGNS AND SYMPTOMS.—In severe cases, the infant appears in the hospital within the first week or two of life. Persistent vomiting is the chief symptom. Infants who appear after the first month of life have less obvious symptoms; there is generally vomiting or constipation unrelieved by dietary control, antispasmodics, and laxatives. Barium studies are usually necessary to make the diagnosis.

TREATMENT.—The same principles of treatment apply as in congenital atresia. The bowel below the stenosis is apt to be more dilated and anastomosis correspondingly easier to perform. While dilatation of a stenosis or local plastic procedures on an obstructing diaphragm may seem simple, both Gross and Wangensteen have observed that they usually fail and should be avoided.

B. MALFORMATIONS OF ANUS AND RECTUM

Congenital malformations of the anus and rectum include a variety of types of atresias, stenoses, and fistulas. Several classifications have been proposed, but that of Ladd and Gross will be followed in this summary. These authors distinguish four types of cases. In Type 1, congenital anal stenosis, the rectum and anus are patent, but stenosis is present 1 to 4 cm. above the anus. In Type 2, the anus is imperforate owing to a thin membranous obstruction, through which a normal meconium stool can be seen. In Type 3, the anus is imperforate, and the rectal pouch ends blindly some distance above it. In Type 4, the anus, sphincter, and lowest portion of the rectum are all normal. About 4 cm. above the anus there is a blind end, separating the anal pouch from the upper rectum (Fig. 51).

Nearly 90 per cent of the malformations fall into Type 3, while the other types are about equally common. The distribution is roughly equal between the sexes.

Fistulas were present in 67 per cent of the males and 81 per cent of the females in the Children's Hospital series. They are rare except in the Type 3 malformation, with which 80 per cent of the patients have an accompanying fistula. In males the fistula runs with approximately equal frequency into the bladder (usually into the trigone), the urethra (prostatic or membranous portions), and the perineum. In the female, rectovaginal fistulas are by far the commonest, rectoperineal fistulas are common and rectovesical fistulas are rare.

SIGNS AND SYMPTOMS.—About three-quarters of the children with anorectal malformations have symptoms of complete or nearly complete ob-

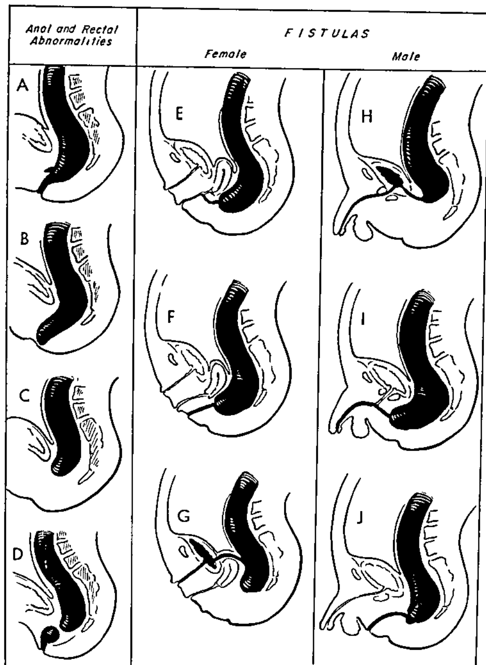


Fig. 51.—Types of malformation of rectum (classification of Ladd and Gross). **A**, (*Type 1*), stenosis of anal canal. **B**, (*Type 2*), thin membrane covering anus. **C**, (*Type 3*), blind rectal pouch. **D**, (*Type 4*), complete separation of rectal and anal pouches. In females, rectovaginal fistula (**E**) is by far the commonest rectoperineal (**F**), common; rectovesical (**G**), rare. In males, rectovesical (**H**), recto-uréthral (**I**), and rectoperineal (**J**) fistulas occur equally commonly.

struction from birth. In the others, if a stenosis is not severe or if a fistula is large enough to prevent obstruction, the diagnosis may not be made for months or years.

Local examination will reveal the lesion. In Type 1, a narrow lumen may be demonstrated by digital examination. In Type 2, the thin diaphragm of the imperforate anus bulges and is stained dark by meconium. In Type 3, there usually is a dimple at the site where the anus should be. A perineal



Fig. 52.—Imperforate anus. Infant has been inverted by Wangensteen-Rice method. Lead marker has been placed in anal dimple. Distal colon and rectum often are delineated better by lateral than by anteroposterior view.

or vaginal fistula can be probed. Urine examination will show the presence of a high fistula, though occasionally repeated specimens are necessary. In Type 4, the blind pouch can be palpated by the little finger inserted into the rectum.

X ray examination is carried out by the Wangensteen-Rice maneuver, in which an opaque marker is placed at the site of the normal anus and the baby inverted so that colonic gas ascends to the upper distal part of the rectum. Lateral films often are superior to anteroposterior exposures. Since in the presence of this type of obstruction, gas passes through the colon slowly, the X ray cannot be depended on to demonstrate the exact site of obstruction until the baby is 24 hours old (Fig. 52).

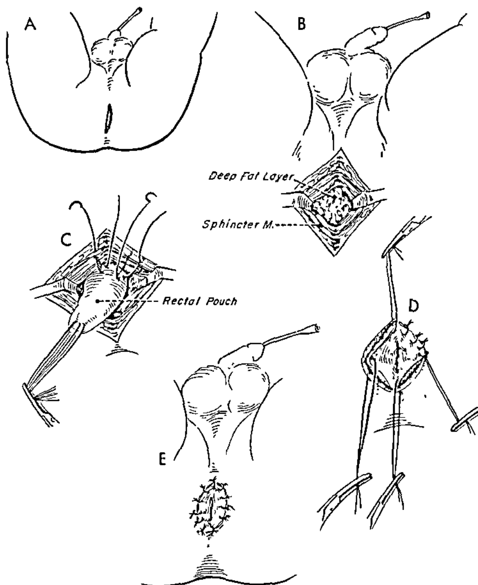


Fig. 53.—Perineal repair of Type 3 malformation of anus without fistula. **A**, preparation of infant, with catheter in bladder. Vertical incision is made at site of anal dimple. **B**, sphincter muscle has been identified and divided into right and left halves. Dissection is deepened through fat layer; rectal pouch is identified. **C**, traction sutures are applied to rectal pouch. It must be widely mobilized, so that there will be no tension after it is sutured. Layer of interrupted sutures of 0000 silk is now placed, uniting muscularis to subcutaneous tissues. ***D**, this blind end of pouch has been excised.* Second layer of sutures of 0000 catgut unites skin to mucous membrane. **E**, completed operation.

Associated congenital anomalies occurred in 39 per cent of Gross's cases.

TREATMENT.—*Type 1.*—The obstruction is usually cured by repeated dilatation of the stricture.

Type 2.—Abnormalities of this type should be treated by excision of the mucous membrane, with suture of mucous membrane to skin.

Type 3.—If the blind rectal pouch extends to within 1.5 cm. of the perineal skin, a perineal operation will be satisfactory. Through an anteroposterior incision extending back to the tip of the coccyx, the external sphincter is divided into right and left halves. Dissection is carried through to the levator ani muscles and the rectum identified and mobilized. The rectum is drawn down and the external sphincter reconstructed. The rectal wall is sutured to the subcutaneous tissues, after which the rectum is opened and the mucosa sewed to the skin. The anus should be made 50 per cent larger than normal to avoid later stricture (Fig. 53).

When the rectal pouch is higher, the preferable operation is done through a combined abdominoperineal approach. However, if the baby's condition is poor, if it weighs less than 6 pounds, if there are severe associated deformities, or if the surgeon has but little experience, a high colostomy is the wisest operation, to be followed by a definitive repair a year or two later (Fig. 54).

The abdominoperineal operation has the advantage of closing all high fistulas at the same time, though it may be accompanied by some loss of control of urine or feces due to nerve damage. After the abdomen is opened, a suprapubic cystotomy is done. The sigmoid is mobilized beyond the blind end and drawn upward, exposing the fistula, which is then clamped and divided. If possible, the fistula should be closed on the anterior side as it enters bladder or urethra. Thereafter, by perineal dissection, the sphincters are identified and spread. The rectum is drawn down through the anal canal and the peritoneum closed in the base of the pelvis. After closure of the abdominal incision, the sigmoid is sutured to the anal margin.

Type 4.—The short segment of distal rectum is difficult to use for an anastomosis. Gross recommends wide mobilization of the rectum and sigmoid through a combined abdominoperineal approach, discarding the distal rectum, and anastomosing the proximal segment to the anus, as illustrated in the Type 3 operation.

C. ERRORS IN ROTATION OF INTESTINE AND COLON

Intestinal obstruction due to errors of rotation arises from an abnormal development of the midgut, which is the section supplied by the superior mesenteric artery. Between the sixth and tenth weeks of fetal life, a portion of the midgut normally extrudes into the umbilical cord. Thereafter, owing

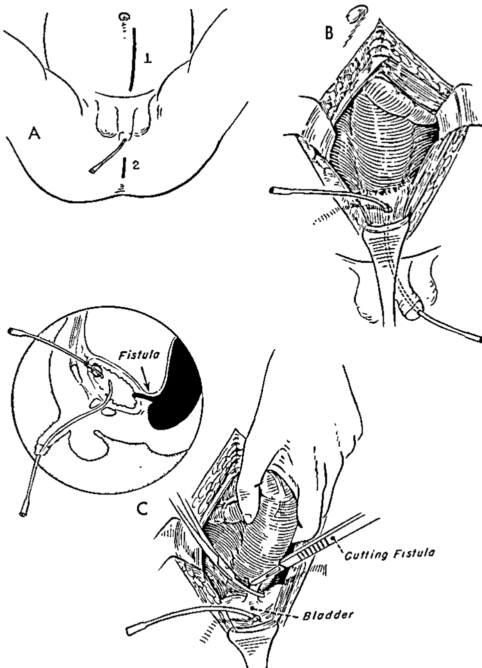
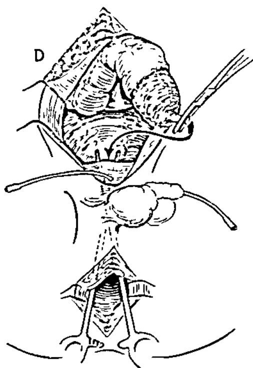


Fig. 54.—Repair of Type 3 malformation of rectum with fistula; combined abdominoperineal approach. **A**, preparation of infant, with abdomen and perineum exposed; catheter is in bladder; sides of incisions are shown. **B**, bladder has been opened and suprapubic cystotomy done. **C**, sigmoid has been mobilized and fistula divided. Inset shows sagittal view **(continued)**.



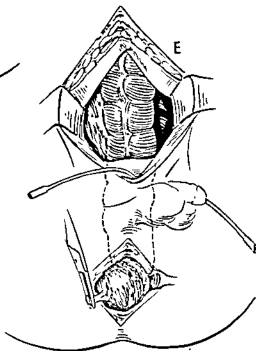


Fig. 54 (cont.).—**D**, perineal dissection has been completed. **E**, rectum has been drawn down through newly formed anal canal (**continued**).

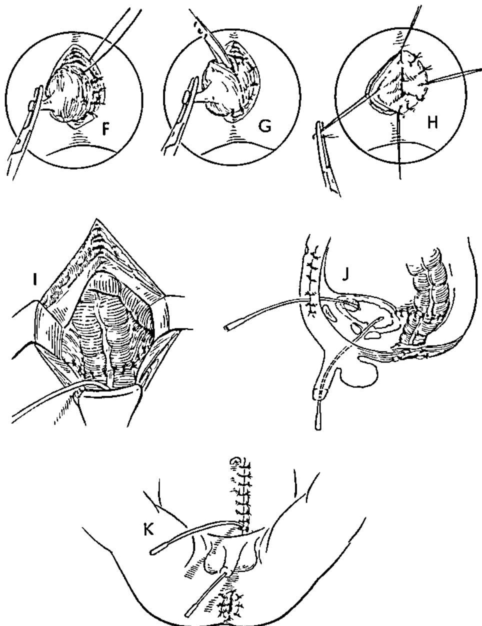


Fig. 54 (cont.).—**F,** rectum anchored to subcutaneous tissue of anus (000 silk). **G,** excess rectum amputated. **H,** mucous membrane anchored to skin (0000 catgut). **I,** closure of peritoneum about lower end of sigmoid. **J,** sagittal section of completed operation. **K,** incision closed.

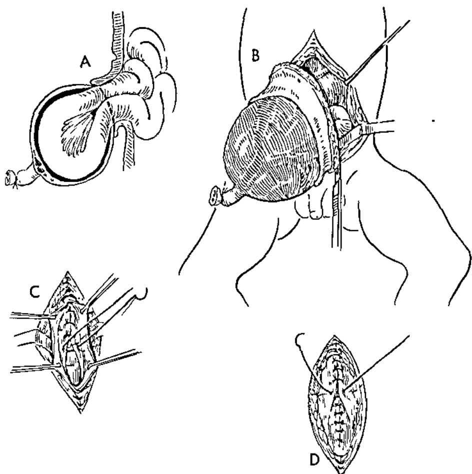


Fig. 55.— Omphalocele. Intestinal obstruction associated with an omphalocele is often due to malrotation. Small omphaloceles can be closed by this method. A, sagittal view. B, excision of normal margin of abdominal wall and entire sac; umbilical vein and arteries must be ligated. C, closure of peritoneum. D, after approximation of rectus muscles, anterior fascia is closed.

to accelerated growth of the abdominal parietes, the midgut is drawn back within the cavity. If this normal development of the parietes does not take place, an omphalocele is produced. Since some of the rotation of the midgut takes place within the umbilical cord, an omphalocele is not necessarily associated with an error of rotation or accompanied by obstruction. In an unusual case reported by Bilderback and Rosenblatt, an unrecognized tiny omphalocele was tied off at the time of delivery and obstruction was caused by the umbilical cord clamp. Recovery followed surgical repair. Gross noted that 28 per cent of his patients with omphaloceles had an error in intestinal

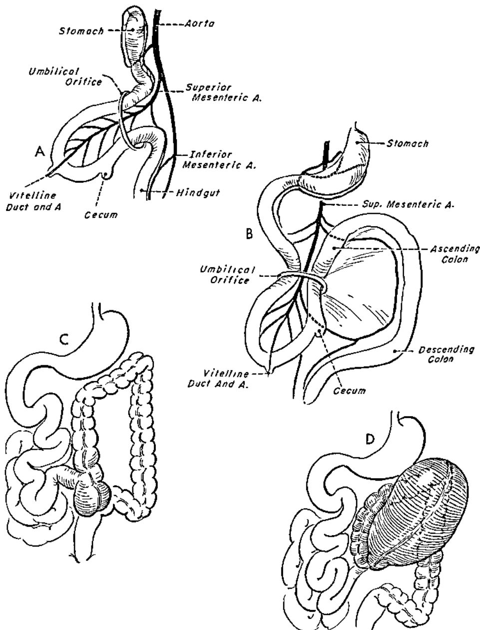


Fig. 56.—Nonrotation of midgut loop **A**, primitive position of midgut loop before rotation has started. Midgut is in umbilical cord (sagittal view). **B**, embryo at eighth week (anteroposterior view). Note that fan-shaped distribution of superior mesenteric axis, which in *A* was in same plane as aorta, has changed from vertical to horizontal position, throwing small intestine to right and large to left. **C**, position of intestine in nonrotation. **D**, intestinal obstruction due to lack of fixation and torsion of cecum.

rotation as well, and this was a likely cause of intestinal obstruction (Fig. 55).

Rotation, according to Dott's classic description, takes place in three stages. In the first, when the midgut loop lies in the umbilical cord, between the fifth and tenth weeks, the future small intestine comes to lie to the right of the vitelline duct and artery, and the future distal ileum and ascending and transverse colon to the left.

The second stage of rotation occurs as the midgut is returning to the abdominal cavity in the tenth and eleventh weeks. During this stage the cecum



Fig. 57.—Nonrotation. Man, 54, operated on for cholecystitis and choledocholithiasis. Preliminary X-ray studies showed nonrotation.

rotates 270° in a counterclockwise direction, anterior to the superior mesenteric artery. Three important errors occur during this stage, as follows:

Nonrotation of the midgut loop is found when rotation stops as the midgut returns to the abdominal cavity. The duodenum descends to the right of the superior mesenteric artery, all of the small intestine lies to the right of the mid-line, and all of the colon lies to the left. When rotation stops at this point, abnormal fixation of the bowel by adhesions is the rule, though in some cases there is no attachment of any portion of the midgut. Not infrequently this abnormality is not discovered until barium examinations in adult life show that nonrotation is present. It has been estimated that it is shown once in 20,000 X ray examinations of adults. Because of the lack of

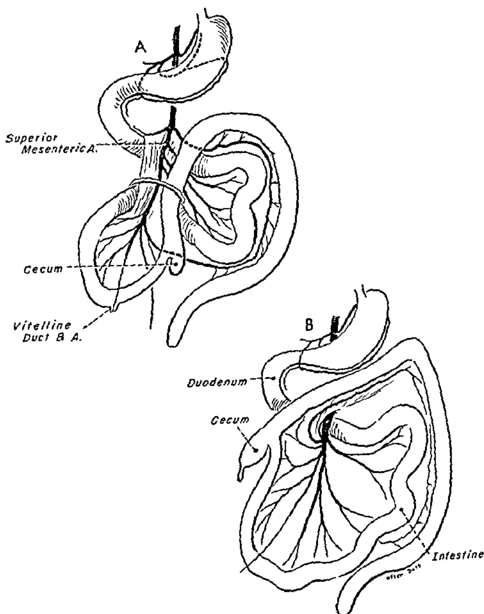


Fig. 58.—Malrotation. **A**, alimentary tract of embryo at 10th week, during the second stage of rotation, as the small intestine enters the peritoneal cavity. **B**, alimentary canal of embryo at 11th week The second stage of rotation is complete, the midgut having rotated 270° counterclockwise **(continued)**.

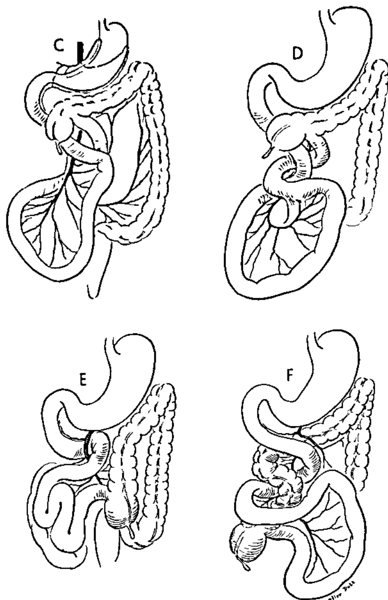


Fig. 58 (cont.).—**C,** malrotation of midgut loop in infants shows same abnormality as *B*. The cecum has become fixed in the right upper quadrant where dense supporting adhesions may obstruct the duodenum. **D,** volvulus of entire small intestine secondary to malrotation. **E,** correction of malrotation that has led to duodenal obstruction by Ladd's operation. This places the bowel in the position of nonrotation. **F,** volvulus of entire midgut loop secondary to malrotation.

normal fixation, the patients are subject to volvulus of some portion of the midgut loop (Figs. 56, 57).

Normally the cecum ascends from the left lower quadrant in a counterclockwise direction through the left upper and into the right upper quadrant. In many instances rotation stops at this point, and *malrotation of the midgut loop* results. The cecum becomes fixed by dense adhesions that run from behind the liver and across the duodenum. At this time the colon remains unattached to the lateral walls of the abdomen, so that the small intestine and colon have a common mesentery, which hangs free on a pedicle composed of superior mesenteric vessels. Obstruction may be due either to duodenal obstruction from the adhesions or to a volvulus of the midgut. This is *by far the commonest abnormality of rotation encountered* by the pediatric surgeon (Fig. 58).

Reversed rotation of the midgut loop is a rare occurrence in which the cecum rotates only 90° but in a clockwise direction. It therefore ends in the right lower quadrant, but the transverse colon lies behind the superior mesenteric vessels and the duodenum in front of them. Obstruction of the transverse colon may occur from compression by the arterial pedicle. Davies, Johanson, and Goldman have collected 32 instances of this rare anomaly. Intestinal obstruction had been present in 25. The types of obstruction fall *into three categories. In the first, obstruction of the transverse colon occurs* because of compression by the superior mesenteric vessels. In the second, there is a volvulus of the right colon or the entire midgut, and in the third, there is duodenojejunal obstruction. In 21 cases in which a laparotomy was done, some type of intestinal resection was necessary in six (Fig. 59).

In the third stage of rotation, the ascending colon and cecum become attached to the lateral and posterior abdominal walls.

CLINICAL FEATURES.—Malrotation of the midgut loop, as stated, is the most important error in anomalies of rotation of the intestine in children. *It is likely to lead to obstruction at an early age.* Of 156 cases in the Children's Hospital, reported by Gross, the symptoms in 87 appeared in the first month of life and those in 40 others before the end of the first year. Koop noted that several hundred cases of obstruction due to this lesion had been reported in the literature. About half of them produced symptoms the first day or two of life and most of the remainder in the first two weeks. Roughly a quarter of the patients had only volvulus of the small intestine, while the others had involvement of the right colon also. The symptoms of pain, nausea, and vomiting may appear soon after birth or later and be mild and intermittent or acute. In adults, abnormalities of the third stage of rotation are common as a cause of obstruction and result in cecal volvulus.

TREATMENT IN CHILDREN.—At the time of operation an adequate inci-

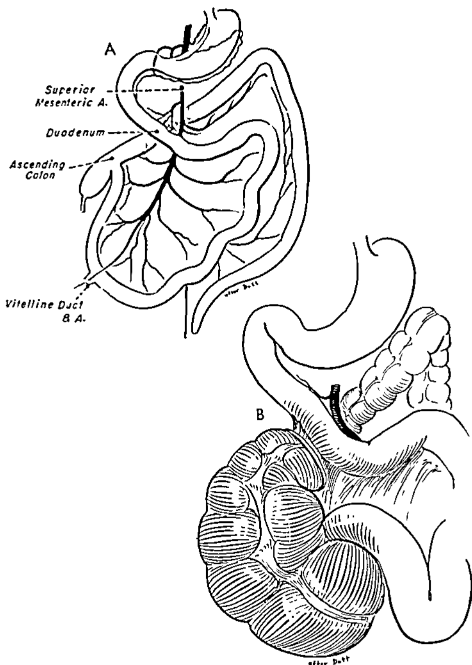


Fig. 59.—Reversed rotation A, in reversed rotation duodenum is anterior to superior mesenteric artery, which in turn is anterior to colon. B, reversed rotation, case with obstruction of ascending colon (After Dott).

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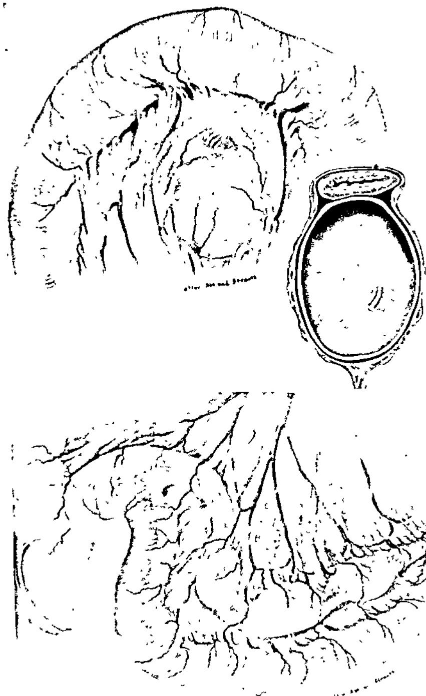


Fig. 60.—Duplications.

sion is essential in order that a thorough exploration can be carried out. If the cecum lies in the right upper quadrant and there is no volvulus, symptoms arise from the adhesions running over the duodenum and binding the cecum in the right upper quadrant. They are divided, and the entire large intestine is then transferred to the left side of the abdomen without an attempt to anchor the colon at any point.

If a volvulus of the midgut is found as well, it must be untwisted, and then exactly the same operation is performed. This operation, described by Ladd, has proved to be very satisfactory.

Any gangrenous intestine must be treated by resection. It may be necessary to excise relatively enormous lengths of gut. Some of the longest intestinal resections recorded have been for midgut volvulus.

TREATMENT IN ADULTS.—The relative frequency of the various anomalies of intestinal rotation in the adult was shown by Findlay and Humphreys, who found 24 cases in the files of the Presbyterian Hospital, New York City. *Errors of the first stage are not seen in adults. Errors in the second stage included 6 cases of nonrotation, 6 of malrotation and 1 of reversed rotation.* Anomalies of the third stage were seen in 6. Of the entire group, 5 patients were asymptomatic, 12 had had chronic symptoms for years, and in 7 the anomaly was discovered during an acute episode.

D. DUPLICATIONS AND CYSTS

Duplications of the intestinal tract vary greatly in size, gross appearance, and location. The lesions are rare. Moore and Battersby, in 1952, described 11 cases and estimated that about 150 had been reported in the literature prior to that time. Gross collected 68 cases from the Children's Hospital *in Boston in the years 1928 to 1950. While duplications arise anywhere from* mouth to rectum, many are asymptomatic, and few of them are associated with the symptoms of intestinal obstruction. Obstruction is more likely to be encountered with duodenal duplications that form large cysts and partially or completely obstruct the duodenum or upper jejunum. In the commonest site, the lower ileum, the duplications tend to be long and tubular and are more likely to be manifested by severe hemorrhage than by obstruction. In the colon or rectum, the upper end of the double colon may function well, but, *if the distal end of one lumen is blocked, fecal accumulation in it will lead to compression and partial obstruction of the other.* An excellent review of 21 cases of doubling of the colon and genitourinary tract has been made by Ravitch.

True duplications differ histologically from mesenteric cysts. Though they may resemble one another, the duplications have a thick smooth muscle

The combination of acute diverticulitis and hemorrhage is encountered most frequently in childhood. Gross noted the presence of gastric mucosa in over half of the patients treated at the Children's Hospital; it is easy, therefore, to understand how peptic ulceration of the diverticulum may occur, with its attendant complications. The bleeding is commonest in infants under 2 years of age; it is painless and usually is so copious that it is bright red. Forty-five per cent of the patients with Meckel's diverticula in the Children's Hospital series entered within the first two years of life.

Intestinal obstruction is the complication noted most commonly in adults. Miller and Wallace collected from the literature 201 cases of abdominal emergencies secondary to these diverticula and found that 45 per cent of the patients had intestinal obstruction. Sixty-three patients had intussusception arising from a Meckel's diverticulum, 26 had obstruction due to some other cause, 93 had ulceration with either hemorrhage or perforation or both, 10 had acute inflammation, and nine had miscellaneous complications. These figures contrast with Gross's series of 130 cases in children, of whom eight had a bowel obstruction, four volvulus of the diverticulum, and twenty-eight intussusception. In a later series of 1,605 collected cases of complications arising from Meckel's diverticula, Moses, in 1947, noted obstruction in 23.8 per cent. This was due to intussusception in 10.9 per cent, volvulus in 1.0 per cent, and other causes in 11.9 per cent.

There are several mechanisms which account for obstruction, as illustrated in Figure 61. According to Ochsner's classification, in the first group complications occur with a free unattached diverticulum. Intussusception is the commonest. A knot may be tied about the gut. A distended or cystic diverticulum may drag, kink, or compress an adjacent loop of small intestine; the diverticulum may fill with enteroliths, gallstones, or other foreign bodies. The intestine may be twisted by a volvulus of the diverticulum. Acute or chronic diverticulitis may narrow the lumen.

In the second group, the diverticulum is attached to the abdominal wall or viscera by a band. The band may interfere with the blood supply of the intestine. An intestinal loop may pass under the bowel or diverticulum and undergo volvulus. The point of attachment of the diverticulum to the abdominal wall may serve as a fixed point about which a volvulus of the intestine occurs. Finally, the intestine may prolapse through an umbilical fistula.

Meckel's diverticulum may also become incarcerated in a hernial sac, producing Littre's hernia. In these instances, strangulation of the diverticulum produces pain and local tenderness. Vomiting is uncommon, and complete intestinal obstruction is rare.

The relative frequency of these abnormalities may be illustrated by

lining; they usually cannot be separated from the intestinal wall. Mesenteric cysts have thin walls and nearly always can be separated readily from the intestine. Mesenteric cysts may be large and produce compression of the intestine and obstruction (Fig. 60).

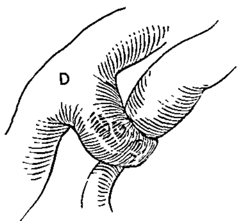
TREATMENT.—The optimal treatment for a duplication is resection of the duplication together with the section of intestine from which it arises, followed by primary anastomosis of the gut. Since this procedure is not always practical, some other method may be necessary. Cysts about the head of the pancreas may be treated by cyst-duodenostomy. In the colon, an anastomosis between the two lumens, near the distal end of the duplication, may be feasible. It is important to remember that resection of a duplication nearly always requires removal of the parent section of bowel, since the two have a single mesentery and the same blood supply.

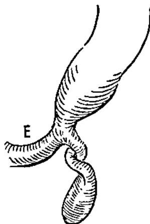
Mesenteric cysts, on the other hand, can nearly always be removed easily, and, if care is taken, the intestinal blood supply will not be damaged and intestine need not be resected.

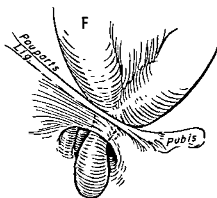
E. MECKEL'S DIVERTICULUM

In the embryo the intestinal tract is connected with the yolk sac by a tract that gradually diminishes in size to form the vitello-intestinal duct. This normally closes completely, but portions of the duct persist in approximately 2 per cent of persons. According to the section of duct that is preserved, different congenital abnormalities are produced. Of these by far the commonest is a diverticulum from the lower end of the ileum, known as Meckel's diverticulum. This represents the persistent proximal portion of the duct. If the distal portion of the duct remains, an umbilical cyst is formed. If the entire duct remains patent, intestinal contents will drain through an umbilical fistula.

Meckel's diverticula can be differentiated easily from other diverticula of the gastrointestinal tract. They are always 12 to 66 inches from the ileocecal valve, though they are usually about 3 feet from the valve in adults and closer in children. They are located on the antimesenteric border of the ileum and often have a true mesentery. They vary in size from a barely visible pouch to a tube nearly a foot long. Histologic examination frequently shows the presence of gastric mucosa or pancreatic tissue. These diverticula rarely cause symptoms and are usually incidental findings at operation or at autopsy. However, they do give rise to a variety of complications that include acute diverticulitis with perforation, intestinal bleeding, intussusception, and intestinal obstruction. In addition, the diverticula may harbor large enteroliths, tumors of various kinds, or primary infection, such as tuberculosis.







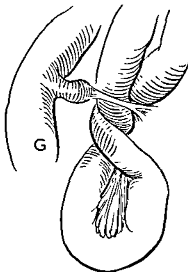


Fig. 61 (cont.).—**D,** compression of adjacent loop of ileum from foreign bodies in diverticulum. **E,** volvulus of diverticulum. **F,** Littre's hernia. Obstruction of intestine usually is incomplete. **G,** volvulus of ileum secondary to band originating from a diverticulum.

Moore's figures. Of 46 symptomatic cases of incomplete duct obliteration, the malformation consisted of a Meckel's diverticulum in 31, a persistent duct in 10 cases, and a diverticulum attached to the umbilicus by a fibrous cord in 5. Intussusception of the ileum onto the abdominal wall through a patent duct occurred in 5 cases.

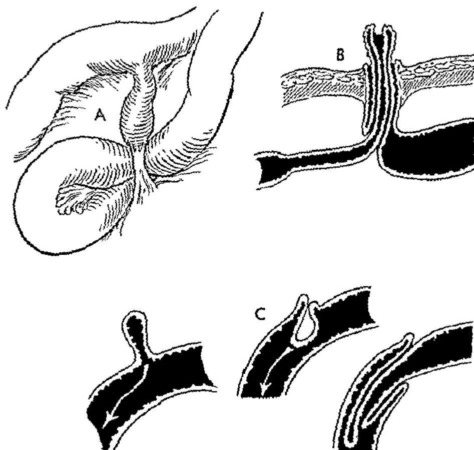


Fig. 61.—Mechanism of obstruction produced by Meckel's diverticulum. A, obstruction due to band extending from tip of diverticulum. B, intussusception through persistent vitteline duct. C, intussusception of the diverticulum (*continued*).

Intussusception due to an invaginated Meckel's diverticulum accounts for approximately 2 per cent of all the intussusceptions. Extensive reviews of this particular complication have been made by Harkins, who collected 160 cases in 1933, and Ponka, who added 54 more in 1956. The mortality in the last series still was approximately 20 per cent.

Diagnosis.—While Meckel's diverticulum may be suspected as the cause of an obstruction, there is no certain way by which a preoperative diagnosis

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Inflammatory Lesions

A. INFLAMMATORY LESIONS OF SMALL INTESTINES

OBSTRUCTION OF THE SMALL INTESTINE by inflammatory lesions intrinsic in that section of the bowel occurs from a variety of causes. They include regional enteritis, tuberculosis, and diverticulitis.

1. Regional enteritis

Regional enteritis often produces partial obstruction and may lead to complete obstruction. This usually involves the lower ileum, though any part of the intestine, including the duodenum, may be affected. Although medical therapy is considered advisable for regional enteritis whenever it is feasible, the presence of obstruction makes operation necessary. There are two schools of thought concerning the type of surgical treatment. One prefers resection of the involved area, the other, a short circuit about the lesion. In the Massachusetts General Hospital, as reported by McKittrick and Risley, resection has been preferred and usually involves resection of the involved ileum, about 10 inches of normal intestine proximal to it, and the ascending colon. Primary end-to-end anastomosis is carried out (Fig. 62).

Those surgeons who employ a short-circuiting procedure on the basis that it is an easier operation, with less postoperative morbidity, prefer an end-to-side ileotransverse colostomy. Side-to-side anastomoses do not defunction the distal ileum and are not recommended unless no active enteritis is present and the obstruction is due to scar. A turn-in of the distal end of the ileum is not wise if the distal ileum is completely obstructed. Instead, it should be brought out through a stab wound, forming a mucous fistula.

2. Tuberculosis

Tuberculosis is still encountered either in the small intestine or in the cecum. In the latter a hypertrophic type of inflammation occurs that may

can be made. In exceptional instances the lesion is diagnosed after administration of barium by mouth, but this method is available only in the absence of obstruction.

TREATMENT.—The proper treatment is release of the obstruction and excision of the diverticulum. Usually this requires only a simple diverticulectomy, though if the diverticulum is gangrenous or if there is thickening of adjacent ileum suggestive of peptic ulceration, it will be safer to resect a short section of ileum.

When diverticulectomy is done, care must be taken to avoid any constriction of the intestine. This may be difficult when the base is broad; then it is best to excise the diverticulum longitudinally and close the intestine in a transverse direction. Two layers of sutures are used unless the lumen of the intestine is so small that only a single layer can be placed. Purse-string ligatures are avoided, since they may narrow the intestine.

When resection of the ileum is necessary, it is best to carry out an immediate end-to-end anastomosis. Gross, however, still believes a Mikulicz procedure is safest.

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quent, only the colon is involved and typical colonic obstruction is produced. This is likely to be somewhat more chronic in its onset than the acute obstruction due to cancer, with slow distention of the proximal colon producing a thickened edematous proximal segment of the colon. More rarely, the obstruction is acute and complete, so that clinically it is indistinguishable from cancer (Fig. 63).

In the second type of obstruction due to diverticulitis, the colon is not ac-



Fig. 63.—Diverticulitis with nearly complete obstruction. Note long involved segment, which is more typical of diverticulitis than of cancer, and relative lack of distention of proximal colon. No diverticula are visualized. Sigmoidovesical fistula developed shortly thereafter, and three-stage resection was performed.

tually obstructed, but peridiverticular adhesions or an abscess causes adhesions of the small bowel. The manifestations are those of small-intestinal rather than colonic obstruction.

Acute obstruction due to diverticulitis, in our experience, is becoming commoner. Requarth noted that less than 2 per cent of all the large-bowel obstructions observed in the Cook County Hospital were due to diverticulitis, while Michel, Thompson, Reinstein, Senter, and Dale found the corresponding figure to be 4 per cent. In the recent Massachusetts General Hospital series, 4.3 per cent of all obstructions and 16 per cent of colon obstructions were due to this disease.



Fig. 62.—Regional ileitis. Patient had subacute obstruction and resection of terminal ileum and right colon were carried out soon afterward. Note "string sign" in distal ileum. Some gas may be observed in small intestine.

partially or completely block the ileocecal valve. For elimination a right colectomy is necessary.

When the disease occurs in the small intestine it may, on healing, form fibrous strictures that can progress to complete obstruction. Resection of the involved area is advisable.

3. Diverticulitis

Diverticulitis of the jejunum or less commonly of the ileum arises from acquired diverticula. Inflammation or impaction with fecal debris may produce obstruction in a manner similar to that of Meckel's diverticulum.

B. INFLAMMATORY DISEASE INVOLVING COLON

1. Diverticulitis

Though diverticulitis is observed in all portions of the colon and the small intestine, it is encountered in 90 per cent of cases in the sigmoid, and nearly all intestinal obstruction due to diverticulitis arises from inflammation in this segment. It is by far the commonest of the inflammatory lesions of the colon that produce obstruction.

The disease may be manifested in several ways. *In the first and most fre-*

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TREATMENT.—When the obstruction is colonic and incomplete and the patient is in good condition, a one-stage resection and anastomosis is indicated. When the obstruction is acute or is associated with a tender palpable mass or fistula formation, a staged procedure is far safer. The surgeon is often in great doubt when he operates on such patients, not knowing whether he is dealing with diverticulitis or cancer. There is a great temptation at the time of laparotomy to determine the diagnosis by palpation. If this is done, palpation must be very gentle to avoid breaking into an abscess. Biopsy of such a mass is dangerous and uninformative. Under no circumstances should the mass be manipulated until the surgeon is prepared to remove it should removal become necessary. This means that the most effective operation for acute obstruction is a transverse colostomy. Unless the diverticulitis is known by accurate X ray studies to be localized in the sigmoid, the stoma should be made in the right upper quadrant. If however, the disease is confined to the sigmoid, a left upper-quadrant colostomy may be done (Fig. 64).

A more difficult situation is encountered when the small intestine is obstructed as well. This exact problem usually is first diagnosed when the patient is operated on for acute small-intestinal obstruction and the diverticulitis discovered. Here the surgeon must be guided by two principles. The small-intestinal obstruction must be relieved, and ultimately the area of diverticulitis must be resected. Usually the obstructing intestinal adhesions can be divided easily. The procedure should be completed by a transverse colostomy in preparation for resection of the colon. The small intestine may be so densely adherent or the mass suggestive enough of cancer to make it unwise to attempt to separate small intestine from colon. In such a case, the intestinal obstruction is relieved by a side-to-side enteroanastomosis and a colostomy done in preparation for later left colectomy.

Some surgeons prefer an exteriorization resection for perforated diverticulitis, particularly when there is a large perforation that cannot be closed satisfactorily and there is perforation into the free peritoneal cavity. In the unusual instance in which acute obstruction and free perforation are both present, this is a proper operation.

After a transverse colostomy for diverticulitis, the sigmoid resection is usually carried out in four to eight weeks. If the patient fails to improve after the colostomy, or if suspicion of cancer exists, the interval is shortened to two to three weeks.

2. LYMPHOGRANULOMA VENEREUM AND OTHER CAUSES OF RECTAL STRICTURE

Lymphogranuloma venereum is by far the commonest cause of inflammatory strictures of the lower rectum. In rare instances stricture due to this dis-

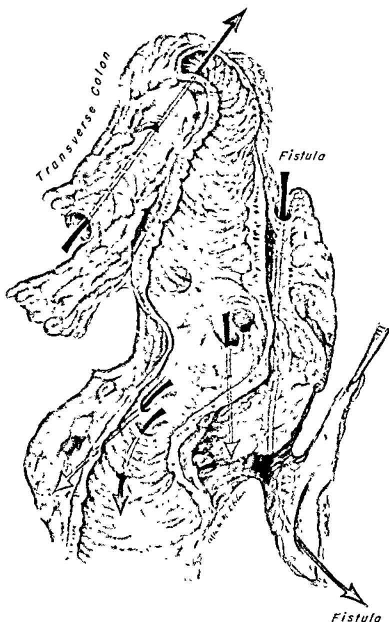


Fig. 64.—Specimen of diverticulitis. Sixty-year-old woman had had a transverse colostomy for acute obstruction due to diverticulitis 9 months previously. Note the numerous fistulas, one of which led to the skin, and another to an abscess overlying left kidney. After left colectomy, a fistula developed which required a later secondary resection. Since then she has remained well. This case demonstrates the complicated nature of an obstruction due to diverticulitis.

ease is found in the sigmoid or descending colon. It produces a chronic, progressive obstruction that becomes more severe as the lumen decreases in size. Complete obstruction should lead the examiner to suspect the secondary development of squamous cell carcinoma, the frequency of which has been reported by some authors, according to the review of Eiseman and Mueller, to be as high as 8.6 per cent.

These strictures are four times commoner in females than in males. Negroes are more frequently affected than whites. The disease is commonest between 20 and 40 years of age.

Constipation, abdominal cramps, and a constant rectal discharge of a mixture of feces, pus, and blood are characteristic. The Frei test is positive. Examination will demonstrate a stricture that usually is tubular in form but may be annular and involves an area that is less than an inch in length.

A large variety of surgical measures have been advised for these strictures. Dilatation is not particularly successful and has led to death from ascending infection. The stricture has been cut both through the rectum and by means of an external rectotomy; cut in either way, the stricture reforms, often denser than before. Colostomy was the only safe method of treatment before the antibiotic era. Bacon, who has had an extensive experience, now prefers transversostomy, followed by abdominoperineal proctosigmoidectomy with preservation of the sphincter muscles. The colostomy incision is closed less than three weeks later, before contraction of the anastomosis occurs. When the disease is extensive, with perirectal abscess or fistula or destruction of the anus or sphincters, the colostomy is followed by a complete perineal excision. Eiseman and Mueller have transplanted a loop of ileum to connect the left colon with the intact anal sphincter after a wide resection.

Inflammatory rectal strictures may be due to other causes. Posthemorrhoidectomy stenosis may be severe. Factitial proctitis may lead to stricture. Radiation reaction following X ray or radium treatment of the pelvic organs may lead to obstruction. Bacterial and parasitic diseases mentioned below may attack the rectum as well as the colon.

3. Ulcerative Colitis

Untreated ulcerative colitis rarely produces a stricture in the colon and complete obstruction. After ileostomy, strictures may develop in various parts of the colon. If multiple, they produce blind segments of colon which gradually distend from a collection of mucus.

When colonic obstruction appears in a patient with known ulcerative colitis, the most likely cause is a secondary carcinoma of the colon. The development of cancer, according to Dennis, is not altered by the presence or absence of an ileostomy. It appears, according to him, about 10 years after the

onset of symptoms of the disease and increases at the rate of about 1 per cent a year. Wheelock and Warren found that in 18.1 per cent of the ulcerative colitis patients in the Massachusetts General Hospital who had not had the colon removed, and had been followed, cancer had developed.

Acute or impending perforation of the colon for ulcerative colitis may



Fig. 65.—Perforation of colon due to ulcerative colitis. This film is not inconsistent with acute colonic distention but in presence of known ulcerative colitis is much more likely to represent impending or actual perforation of colon. At operation, done soon after film was taken, several perforations were found. Subtotal colectomy was carried out, and patient survived.

mimic acute obstruction very closely, and, unless the underlying disease is suspected, the wrong operation may be done. Impending perforation is manifested by abdominal distention, tenderness along the course of the colon, diminished peristalsis, and great gaseous distention of the involved loop of colon, demonstrated by X ray. If the surgeon believes he is dealing with an acute colon obstruction due to diverticulitis or cancer, he may erroneously

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Tumors

A. CANCER OF COLON

CARCINOMA OF THE COLON is by far the most frequent cause of large-bowel obstruction. Symptoms of chronic obstruction are observed in nearly 50 per cent of all patients with such cancer. Acute obstruction was found in 18.7 per cent of 1,092 patients with cancer of the colon treated in the University of Minnesota Hospital, as reported by Smith, Gott, Crisp, and Perry.

When all acute colon obstructions at the Massachusetts General Hospital are considered, cancer accounts for approximately 80 percent of the cases, with the remainder divided between diverticulitis and volvulus. The acute obstructions due to cancer are commonest in the sigmoid. The rectum, right colon, and splenic flexure are sites of obstruction in decreasing frequency. Lockhart-Mummery, in a series of 90 cases of acute obstruction due to cancer of the colon, found the site of the cancer to be the rectum in 20, sigmoid in 30, splenic flexure in 28, transverse colon in three, and right colon in seven. Cancer of the cecum readily obstructs the ileocecal valve, but relative freedom of the upper right colon is dependent on several factors. The lumen of the colon is distinctly wider on the right than on the left. Fecal matter is much thinner on the right than on the left. Polypoid cancers are relatively commoner on the right, and stenosing lesions, on the left. The relative frequency is demonstrated in Table 7, covering the material in the present study.

SYMPTOMS.—The common diagnostic features of acute obstruction of the colon due to cancer have been discussed but will be recapitulated briefly here. Ordinarily some digestive symptoms exist prior to the acute attack. With obstruction on the right side, these symptoms are apt to be indefinite and vague and are often accompanied by anemia or diarrhea. With obstruction

perform a colostomy. The proper operation for perforating ulcerative colitis is either subtotal or total colectomy (Fig. 65).

Postoperative obstruction after ileostomy or colectomy for ulcerative colitis is common. It will be discussed in Chapter 25.

A closely related lesion is regional or segmental colitis. While its relationship to true ulcerative colitis is not clear, it is a rare cause of intestinal obstruction. Among 201 patients with this disease observed by Neuman, Bargen, and Judd, only one had preoperative symptoms of obstruction.

4. Other inflammatory lesions

Other granulomatous diseases, either bacterial or parasitic, that involve the colon may mimic carcinoma closely. *Amebiasis* may produce an inflammatory tumor that obstructs the colon completely. The cecum usually is involved, but the transverse or left colon may be the site of the granuloma. *Schistosomiasis* can produce rectal polyps and obstruction. *Actinomycosis* is more likely to result in fistula than in obstruction. *Tuberculosis* may lead to a hyperplastic ileocecal mass and obstruction or form an inflammatory stricture elsewhere in the bowel. The *dysentery bacillus* may produce ulceration and stricture. It is probable that the so-called *syphilitic* strictures actually are due to lymphogranuloma venereum.

C. EOSINOPHILIC GRANULOMA

Eosinophilic granuloma is one of the rare causes of intestinal obstruction. Virshup and Mandelberg were able to collect 23 cases in which this disease was encountered in the gastrointestinal tract. It is commoner in the stomach and duodenum; in only seven cases was there a lesion in the jejunum, colon, or ileum. The symptoms are those of intestinal ulceration or obstruction. That some sensitization reaction is involved is evidenced by the marked eosinophilia that often occurs. Clinically, the lesion appears as a tumorlike mass or as an infiltrating lesion. The treatment is surgical excision. Several cases of pyloric obstruction from this cause have been described by McCune, Gusack, and Newman.

ever, cancer at the ileocecal valve or cancer of the right colon with an incompetent ileocecal valve produces repeated attacks of vomiting associated with epigastric cramps that are suggestive of small-bowel rather than colonic obstruction.

PHYSICAL FINDINGS.—The degree and nature of the distention vary according to the function of the ileocecal valve. When it is competent, as it is in approximately 60 per cent of all obstructions due to colon cancer, the distention involves the colon alone. A mass forms that corresponds to the anatomic outline of the obstructed section of the colon. It can be seen and palpated through the abdominal wall. If the distention has progressed slowly, the mass will be soft and putty-like and full of feces. If the obstruction is acute, with few preliminary symptoms, the distention is more apt to be due to gas. Peristalsis is high-pitched. Unless relief is obtained, the distention will lead to local areas of gangrene and perforation. They nearly always occur either at the site of the tumor or in the cecum, for reasons listed in Chapter 5.

Whether or not a tumor is palpable on rectal examination it is wise to perform a sigmoidoscopy. It must be done with a minimum of trauma, as little air as possible being introduced. This examination must precede the barium enema, or the bowel wall will become difficult to visualize because of injected barium.

X RAY EXAMINATION.—The scout film should suggest the diagnosis of acute obstruction of the colon, though it will not serve to rule out primary colonic ileus. Whenever the nature of the obstruction is not clear, a barium enema is necessary. This must be employed with circumspection, since a large amount of barium can be injected above a partially obstructed cancer and produce technical difficulties during succeeding operative procedures. The barium enema usually gives definite information, so that the course of action becomes clear.

When the barium enema does not demonstrate an obstructing lesion, the surgeon must recall the fact, emphasized by Wangensteen, that obstructing cancers of the left colon occasionally cannot be demonstrated by a barium enema and that the barium enema is much less accurate with such cancers than it is in the diagnosis of nonobstructive cancer. At the Massachusetts General Hospital we have made the same observation. The surgeon may have to proceed with an operation and find an acute colic obstruction despite the negative evidence offered by the barium enema.

Occasionally the barium demonstrates a block and no lesion is present. This pseudo-obstruction is most likely to be encountered at the splenic flexure. It will be discussed in Chapter 23, Section B.

DIFFERENTIAL DIAGNOSIS.—The important lesions that must be considered in the differential diagnosis include large-intestinal obstruction due to

TABLE 7.—ACUTE OBSTRUCTION, CANCER OF COLON AND RECTUM, MASSACHUSETTS GENERAL HOSPITAL, 1947-1955

A. DISTRIBUTION OF CASES

	TOTAL NO. OF CASES	PERCENTAGE OF TOTAL
Cecum	13	6.1
Ascending colon	7	3.3
Hepatic flexure	7	3.3
Transverse colon	13	6.1
Splenic flexure	22	10.2
Descending colon	14	6.5
Sigmoid	97	45.0
Rectum	42	19.5

B. MORTALITY ACCORDING TO OPERATION AND SITE OF TUMOR

	RESECTION				PALLIATIVE OPERATION		NO OPERATION		TOTAL
	1-STAGE		2-STAGE						
	L	D	L	D	L	D	L	D	
Cecum	5	2	1	2	1	1		1	13
Ascending colon	3	1	2		1				7
Hepatic flexure	3		1		3				7
Transverse colon	4		4		3	1	1		13
Splenic flexure	3		6	3	5	5			22
Descending colon	2		5	1	3	3			14
Sigmoid	7*		48	12+	24	4		2	97
Rectum	1		14	1	19	7			42
Total	28	3	81	19	59	21	1	3	215

* In 6 cases obstruction was subacute.
+ In 6 instances 1st stage only was carried out; the patients died before an apparently resectable lesion could be removed.

C. MORTALITY ACCORDING TO OPERATION

	TOTAL NO. OF PATIENTS	DIED	MORTALITY, %
One-stage resection	31	3	9.7
Two-stage resection	100	19	19.0
Palliative operation	80	21	26.2
Cecostomy	66	18	27.3
Transverse colostomy	67	12	17.9
Cecostomy followed by colostomy	6	1	16.7
Over-all mortality	215	46	21.4

on the left, a change in bowel habit occurs, consisting either of diarrhea, of constipation, or of alternating periods of the two. Small amounts of bright blood or bloody mucus may be discharged frequently by rectum independently or in conjunction with bowel movements. A loss of weight follows voluntary food reduction. Finally the symptoms of acute obstruction are superimposed on this pattern. Typically, acute obstruction is marked by large-bowel cramps and by obstipation, while nausea is absent or minimal. How-

until recently. The main arguments in their favor were as follows. 1. Obstruction was relieved by the first operation, so that the definitive operation could be carried out under more satisfactory conditions, including good bowel preparation and antibiotic protection. 2. Staged operations were simpler and shorter, reducing postoperative morbidity and mortality. 3. The peritoneal cavity, entered two or more times in short order, was presumed to be "vaccinated" by the first procedure and serious sepsis, therefore, less likely to occur at the time of the resection.

The third hypothesis has never been proved. The second argument has been practically eliminated by the introduction of new methods of anesthesia and by better fluid, electrolyte, and blood administration, more extensive operations being far safer now than they were a few years ago. The first objection remains as a valid and important criticism.

On the other hand, there are numerous arguments against two-stage resections. The offending cancer is left in place between the two stages and there may be a serious delay, allowing spread of the tumor, if complications follow the first operation. Certain complications are inherent in and may arise from the first operation. Thus, a side-to-side ileotransverse colostomy about an obstructing cancer of the right colon is not infrequently followed by herniation of a loop of proximal small intestine behind the anastomosis, with production of a secondary high intestinal obstruction.

The advocates of primary resection for obstructing lesions have other arguments in their favor. This method has proved the best in the small intestine, so it seems logical that it should be extended to the large. Furthermore, many cancers treated by "blind" cecostomy or colostomy are found at laparotomy a week or two later to be completely irremovable; valuable time and expense would have been saved if this fact had been determined at the first operation. It may be pointed out that in early acute obstruction, the colon is distended by gas that can be aspirated, allowing resection under relatively favorable circumstances.

No final conclusions can be drawn, but the following seem justified at the present time. "Blind" cecostomy or transverse colostomy should be reserved for poor-risk patients. Generally, exploration should be carried out to determine whether the cancer is operable or not. Patients with chronic incomplete obstruction preferably are treated by one-stage resection and anastomosis if they are in good general condition. When resection is employed for acute obstruction, great circumspection must be used. The operation is relatively safe when the anastomosis is made between terminal ileum and nondistended colon distal to the excised growth. It is highly dangerous when the final anastomosis is made between a distended proximal colon, full of feces, to distal colon. In the presence of acute obstruction, trivial technical problems

diverticulitis or to volvulus, colonic ileus, and small-intestinal obstruction.

Diverticulitis cannot be distinguished from cancer when complete obstruction prevents delineation of the lesion by barium enema. In about 18 per cent of all our cases of resection for diverticulitis the exact diagnosis was in doubt until the specimen was opened. Consequently, a number of patients with obstruction from acute diverticulitis will have a decompressive procedure carried out on the assumption that the lesion is cancer. Fortunately the erroneous diagnosis makes little difference in therapy, since decompression and resection are necessary in both cases.

Volvulus of the sigmoid, cecum, or transverse colon may produce acute obstruction that erroneously is ascribed to cancer of the colon. This is a serious error because the wrong operative procedure may be carried out. For example, transverse colostomy for volvulus of the sigmoid may lead to a fatality, since the unsuspected twisted loop may become gangrenous and perforate. Volvulus can usually be suspected from the scout film and should be diagnosed by the barium enema with demonstration of the characteristic "bird-bill" deformity.

Colonic ileus is the disease most likely to be confused with obstruction due to cancer. As will be pointed out in a later section, this type of ileus may be associated with many diseases but occurs in a primary form with which no other disease can be identified. The abdominal plate showing severe colonic distention and a barium enema that shows no definite lesion are not incompatible with obstructing cancer. Even with this disease, however, a decompressive procedure may be necessary and may be lifesaving.

Small-intestinal obstruction may be erroneously labeled colic obstruction, and vice versa. It is obvious that unless the surgeon exercises great caution, disaster may result. It must be reiterated that when the diagnosis of obstruction has been made, the first duty of the surgeon at laparotomy is to determine whether intestine or colon is involved and then proceed with therapy. For example, if a surgeon plans a "blind" cecostomy or transverse colostomy but fails to find a distended cecum or transverse colon, a further incision must be made and the remainder of the intestinal tract inspected, since the causative lesion is most likely to be a small-bowel obstruction or a volvulus of the sigmoid.

Treatment.—The accepted optimal therapy of cancer of the colon is primary resection and anastomosis. Since this procedure, unfortunately, has been found to be dangerous when acute, high-grade obstruction is present, side-tracking operations for obstructing right-colon cancer and decompressive procedures for those of the left side are favored as the first moves in staged resections. These competing methods need closer examination.

Staged operations on the colon were generally accepted and applauded

Early ligation reduces the likelihood of heptic metastasis, according to evidence presented by Fisher and Turnbull.

(*a*) *Cancer of right colon with obstruction.*—The right section of the colon should be subdivided into the cecum, ascending colon, and hepatic flexure, since cancer tends to behave somewhat differently in each of these sites.

Cancer of the cecum usually produces a clinical picture of small-intestinal obstruction. The tumor rapidly blocks the ileocecal valve, producing small-

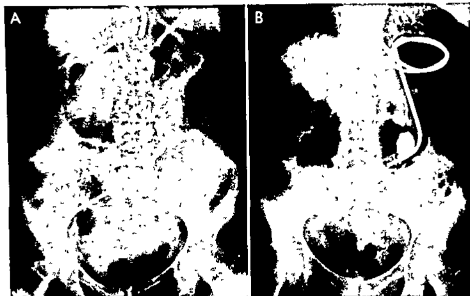


Fig. 66.—**A**, obstructing cancer of cecum. Woman, 73, had had epigastric and right lower quadrant cramps of week's duration. Note distended loops of small intestine. There is small amount of gas in colon and rectum. At operation, cancer of cecum was found and primary resection carried out. **B**, obstructing cancer of ascending colon. Woman, 81, had had severe uppper-abdominal pain and vomiting of five hours' duration. Admission X ray shows no small-bowel distention and some gas in colon. Laparotomy, carried out soon after entry, revealed cancer of mid-ascending colon with closed-loop obstruction. Cecum was necrotic and full of fluid.

intestinal epigastric cramps and an X ray picture typical of small-intestinal obstruction. No distention of the colon occurs, and, unless a barium enema is administered that demonstrates the lesion, the diagnosis may remain obscure until exploration is done.

Since cecal obstruction mimics simple small-bowel obstruction, there may be a tendency to procrastinate in the hope that long-tube deflation may be accomplished before laparotomy. Such a procedure may be disastrous, because the cancer may perforate during this period (Fig. 66).

may be magnified to serious difficulties. If resection is carried out in the presence of any significant distention, the bowel must be deflated in some fashion at the time of operation; this usually requires concomitant cecostomy or transverse colostomy. Moreover, the fundamental principles of an operation for cancer must not be compromised.

No adequate data is available to indicate the relative safety of these two methods, since every surgeon exercises the factor of selection. However, statistics from two institutions that have extended the indications for primary resection and anastomosis are of interest.

Primary resection and anastomosis of the distended left colon has been found to carry a forbidding mortality in the University of Minnesota Hospital. Smith *et al.* reported two deaths among nine patients treated in this fashion. This mortality of 22 per cent contrasted with a rate of 3.6 per cent for 28 similarly treated lesions in the absence of distention. Among 65 patients with severe distention of the left colon treated by transverse colostomy, the mortality rate was 4.6 per cent. In the same institution, primary resection and anastomosis of the obstructed right colon carried a mortality of 11 per cent, but this high rate was ascribed to an inordinate hospital delay before operation.

Gregg advised primary resection and anastomosis of the colon (1) when there is regurgitant obstruction with an incompetent ileocecal valve; (2) when the entire obstructed segment can be removed, even if the obstruction is of the closed-loop type; (3) whenever, regardless of the type of obstruction, the bowel returns to relatively normal size when aspirated by trochar; (4) when there is imminent or actual perforation, in which case it may be safer to remove the entire devitalized bowel than to establish a vent through the compromised bowel. These criteria being followed, in 16 cases of early perforating and obstructing lesions of the colon resection was performed without mortality. His selection of cases for primary resection and anastomosis appear very logical.

The operative procedures for cancer of the colon vary according to the location of the primary tumor. In the Massachusetts General Hospital, segmental resection and primary anastomosis is the procedure of choice, while subtotal or total colectomy is reserved for cancer arising in ulcerative colitis and for multiple polyps or cancers. Consequently the operative maneuvers differ for each section of the colon. Any resection of the colon for cancer should be preceded by isolating the tumor. Ties are placed about the colon a short distance on either side of the tumor according to the technique developed by Cole. Usually it is possible to tie the corresponding mesenteric vessels at a comparatively superficial level, while the final division of artery and vein will be done at a later time near the conclusion of the resection.

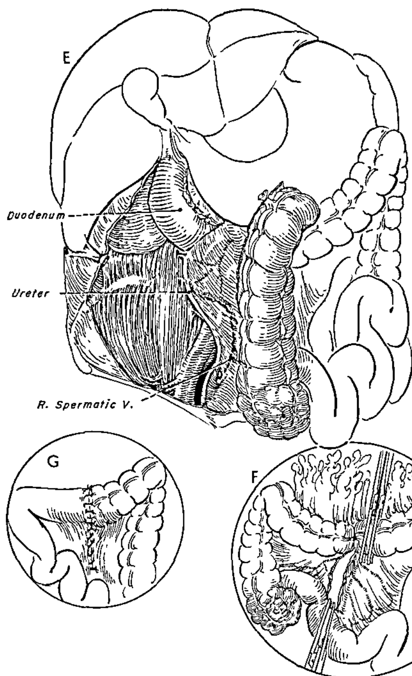


Fig. 67 (cont.).—E, right colon has been mobilized and turned medially. Ureter and duodenum have been completely isolated. Right spermatic or ovarian vein has been ligated and is removed with mesentery of colon. **F,** mesentery is divided and hemostasis secured. Clamps are applied and specimen removed. **G,** end-to-end anastomosis has been completed and rent in mesentery closed.

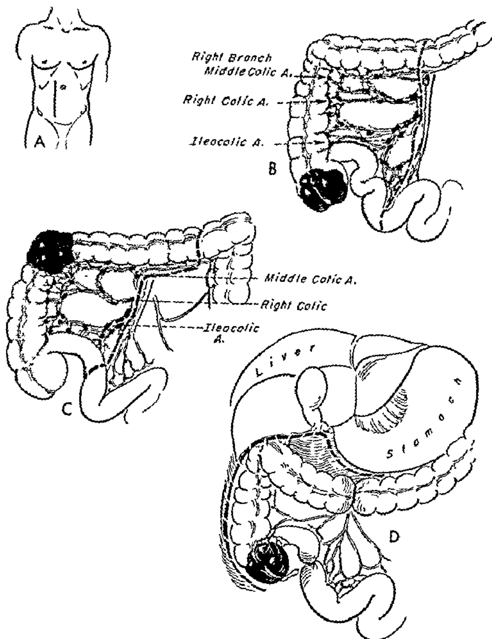


Fig. 67.—Operations for cancer of right colon. **A**, right paramedian incision is preferred. **B**, extent of resection for cancer of cecum. **C**, extent of resection for cancer of hepatic flexure. Mid-colic artery is ligated at base. Preliminary ligation of large vessels in segment to be removed may be done. **D**, mobilization of colon is preceded by ligature of bowel on both sides of tumor. Right colon is freed along avascular lateral attachments. Suspensory ligaments at hepatic flexure contain blood vessels and must be ligated (**continued**).

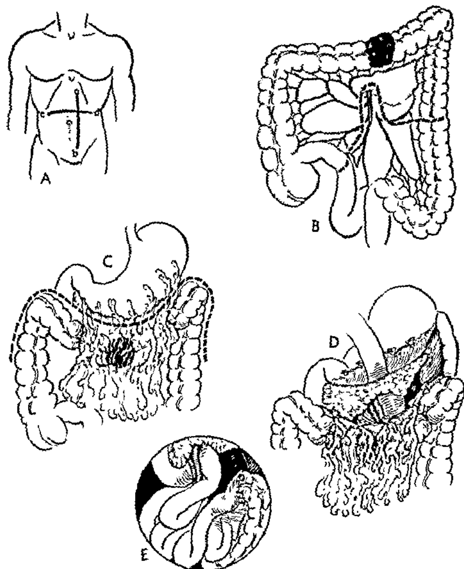


Fig. 68.—Resection for cancer of mid-transverse colon. A, left paramedian or long upper transverse incision may be used. B, anatomic extent of dissection will vary, depending upon many factors. A satisfactory operation, from the point of view of a wide resection of mesenteric nodes, is shown here. C, right colon, splenic flexure, and descending colon must be mobilized widely, as shown by dotted line. D, detail of resection. Colon has been mobilized by cutting along dotted line in C, and usually gastroepiploic lymph nodes are removed with specimen. Vascular lienocolic ligament must be divided and ligated. E, final ileo-descending colostomy (*continued*).

Cancer of the ascending colon less commonly leads to acute obstruction, because the colon is so wide in this area that a very bulky tumor is required to block the lumen. Such a tumor usually can be palpated easily on physical examination, and diagnosis, therefore, is not difficult.

Cancer of the hepatic flexure may produce acute obstruction, but this is the flexure in which obstructions are encountered least frequently. A distended ascending colon, visualized on the scout plate, is statistically much more likely to be due to cancer of the splenic than to cancer of the hepatic flexure, as Lockhart-Mummery has noted.

The operative procedures available for the relief of obstructing cancer in this section of the bowel are as follows.

(1) One-stage right colectomy. This is the operation of choice. Preliminary intubation by intestinal tube is advisable preoperatively, but the period of preparation should not exceed 12 hours because of the danger of perforation. Operative decompression will usually be necessary. This generally can be accomplished by aspiration through an enterotomy incision in the terminal ileum, a section of the intestine that will be included in the resection being used. A catheter can be passed through the ileocecal valve and the ascending colon decompressed even in the presence of a competent valve. Primary resection and anastomosis usually can be done with relative ease (Fig. 67).

(2) Two-stage right colectomy. This may be required if the patient is a poor risk. In the presence of an incompetent ileocecal valve, a side-to-side ileotransverse colostomy is best. Some surgeons approve of a tube cecostomy proximal to an obstructing cancer of the hepatic flexure if the ileocecal valve is competent. This procedure contaminates the abdominal wall, makes the resection more difficult, and is not to be recommended when any alternative exists. Appendicostomy is a poor method to deflate a distended colon and should not be used. An ileostomy (either catheter or defunctioning) will relieve the obstruction but complicates the resection and is not advisable.

The extent of the resection for cancer of the hepatic flexure was clarified by Phillips, Waugh, and Dockerty. They studied the lymphatic spread from cancer of the hepatic flexure and found that the lymphatic chain accompanying the right branch of the middle colic artery was the principal route of metastasis. To extirpate the middle colic lymph chain it is necessary to remove the entire middle colic artery. The right colic and ileocolic arteries, which are secondary routes of metastases, also must be included in the dissection. If, on the other hand, the cancer is in the cecum or low ascending colon, the left branch and main stem of the middle colic artery need not be removed.

(*b*) *Carcinoma of transverse colon with obstruction.*—It is fortunate that

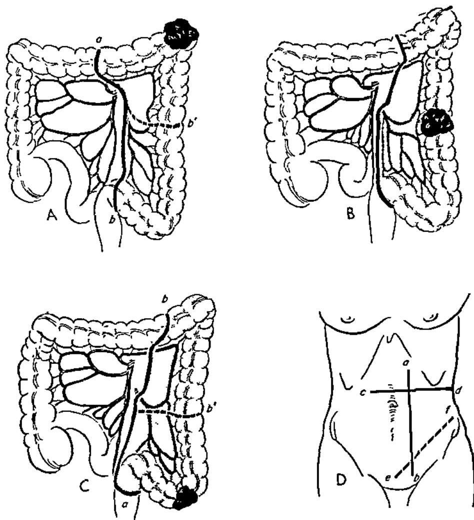


Fig. 69.—Anatomic extent of resections, cancer of left colon. A, cancer of splenic flexure. *ab*, resection of left branch of mid-colic artery and ligation of inferior mesenteric artery at source. Anastomosis will unite mid-transverse colon to intraperitoneal rectum. *ab'*, ligation of left colic artery at origin and left branch of mid-colic artery at origin. Anastomosis is made between mid-transverse and mid-descending colon. B, cancer of descending colon. Inferior mesenteric artery is ligated at origin. Anastomosis is made between mid-transverse colon and intraperitoneal rectum. C, cancer of sigmoid. Assuming that 10 cm. of colon can be resected distal to cancer, anastomosis is possible; any margin less than 10 cm. is compromise. *ab*, left colectomy with ligation of inferior mesenteric artery at origin is the operation of choice. *ab'*, conservative resection with ligation of inferior mesenteric below origin of left colic. Anastomosis will unite descending colon to intraperitoneal rectum. D, incisions. *ab*, for left colectomy, left paramedian is best. *cd*, for conservative resection of splenic flexure. *ef*, for conservative resection of sigmoid.

obstructing carcinomas of the transverse colon are rare, because the associated technical problems may be the most difficult that arise in any segment of the colon. If the obstruction is subacute, located just distal to the hepatic flexure, and there is reflux through an incompetent ileocecal valve, a day or two of decompression by an intestinal tube then is indicated to allow preparation of the patient in the hope that a primary resection may be facilitated.

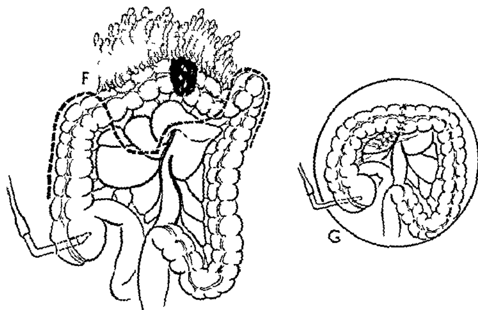


Fig. 68 (cont.).—F, conservative resection for cancer of mid-transverse colon. Both hepatic and splenic flexures are mobilized. Only the mid-colic and right colic vessels are excised. Cecostomy had been done previously G, colo-colostomy completed.

If, however, the obstruction is acute, operation is urgent. The possible procedures include the following.

(1) Primary resection and anastomosis. This may be feasible, but enormous distention of the right colon proximal to the tumor renders it dangerous. Nevertheless, if the patient is in good condition and distention is not excessive, it is the best operation. The surgeon must recognize the fact that the resection may be difficult and that aspiration of solid fecal masses from the obstructed colon may be impossible. The entire distended segment of colon should be removed (Fig. 68).

Until recent years, an adequate operation for cancer of the transverse colon involved resection of a relatively short length of colon and mid-colic vessels. This is not considered extensive enough at the present time if the patient is a good operative risk, as shown by the mortality data of Welch and

tention of the colon. Operative decompression must be carried out at once if perforation of the cecum is to be prevented. Intestinal tubes should not be used in preparation because valuable time will be lost.

Decompression may be effected by cecostomy or colostomy. Immediate cecostomy is the most satisfactory method. It will relieve the obstruction and provide enough mobility of the colon for the wide resection required in the second stage. Right transverse colostomy provides better preparation of the colon but may hamper the surgeon seriously at the time of the resection.

Primary resection and anastomosis of this segment of the colon is the preferable operation if the obstruction is subacute and is accompanied by only minimal distention of the proximal colon. At the time of operation, much of the fecal matter in the proximal colon can be milked into the excised segment of colon, this procedure facilitating the anastomosis (Fig. 69).

(*d*) *Carcinoma of sigmoid or rectum with obstruction.*—This is the section of the large bowel in which resection and anastomosis have proved to be dangerous in the presence of acute obstruction. Some patients with mild obstructive symptoms can be tided over, prepared by enemas and phthalylsulfathiazole or neomycin by mouth, and operated on safely by primary resection and anastomosis (Figs. 71, 72). Acute obstruction, manifested by continuing crampy pain or serious distention, indicates an immediate decompression procedure.

A good deal of information may be obtained from the abdominal X ray. If the colon is relatively normal in diameter, there usually is no urgency. If there is definite distention, the surgeon must select the best method of relieving the distention and carry it out as soon as possible (Fig. 70).

Lowman and Davis have studied the size of the cecum in seven patients with perforation, and find that this catastrophe did not occur when its diameter was less than 9 cm. They believe this is the critical level and that immediate surgery should follow the demonstration of this amount of distention, since mortality after cecal perforation is about 75 per cent.

In the writer's opinion the operation of choice under these circumstances is cecostomy unless the colon is packed with feces or a mixture of feces and barium. In such instances transverse colostomy is wise. There obviously is a great division of opinion about the proper operation in these circumstances,

B. OTHER TUMORS

Intestinal obstruction may be produced by other tumors, though in comparison with cancer of the colon they are all rare. Malignant tumors of the since many surgeons prefer transverse colostomy as a routine. The arguments have been considered in a previous chapter.

Giddings and by the studies of McKittrick and Wheelock. Neither is it wise in the presence of distention, because the anastomosis would be made with the obstructed proximal colon. It is now believed that the ileocolic, right, middle, and left colic arteries should be removed with attendant lymph nodes, and the ileum anastomosed to descending colon or sigmoid in order to achieve an adequate dissection.

(2) Anastomosis of ileum to colon at site well beyond cancer, to be followed by right, or subtotal, colectomy. Since the midcolic vessels must be



Fig. 70.—Enormous distention of cecum secondary to obstructing cancer of sigmoid.

resected at the time of the colectomy, it is better to anastomose the ileum to the left colon and later resect the entire colon proximal to the anastomosis.

(3) Cecostomy followed by transverse or subtotal colectomy. This is a *satisfactory method if the tumor is in the left transverse colon or if excision* of only a short segment of colon is planned. However, with carcinoma of the proximal or mid-transverse colon, it is advisable to resect the entire right colon as well, in order to secure adequate avenues of nodal spread and to procure an anastomosis free of tension. If this is done, the cecostomy stoma must be taken down at the time of the resection.

(c) *Carcinoma of splenic flexure or descending colon with obstruction.* —Obstruction at this site nearly always is acute, with serious proximal dis-

tention of the colon. Operative decompression must be carried out at once if perforation of the cecum is to be prevented. Intestinal tubes should not be used in preparation because valuable time will be lost.

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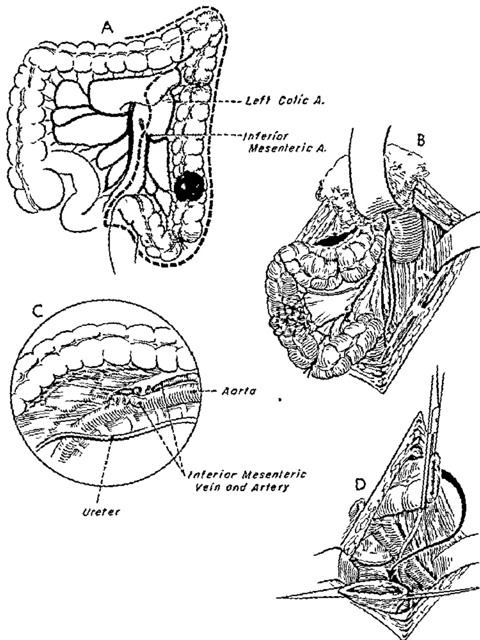
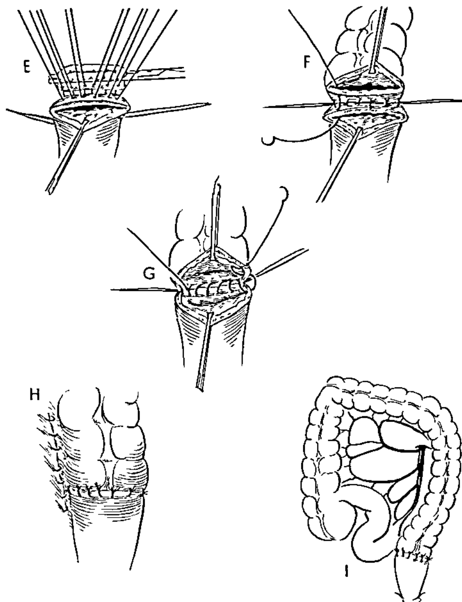


Fig. 71.—Left colectomy for cancer of descending colon and sigmoid. **A**, extent of resection is shown in crosshatched area. Ties are placed about bowel on either side of tumor. Mobilization of lateral attachments free descending colon. Gastrocolic omentum is divided. Cololienal ligament contains blood vessels that must be ligated. **B**, left colon has been freed and turned medially. Ureter is exposed. Left spermatic (or ovarian) vein has been ligated distally and then proximally and will be removed with specimen. **C**, colon is swung medially. Inferior mesenteric artery now can be



divided at origin and vein at slightly higher level. Colon is then resected. It may be possible to use clamps on lower end, but usually line of resection is only 3 to 4 cm. above peritoneal floor, so clamp cannot be placed on distal rectum. **D,** upper colon is now swung downward and open end-to-end anastomosis made. **E,** outer posterior row of sutures (00 silk or #30 cotton). **F,** inner posterior row is started (000 catgut). **G,** completion of inner posterior layer. Catgut is continued to form inner anterior layer. **H,** anastomosis has been completed by an outer anterior layer, and mesenteric defect closed. **I,** diagram of colon at conclusion of anastomosis.

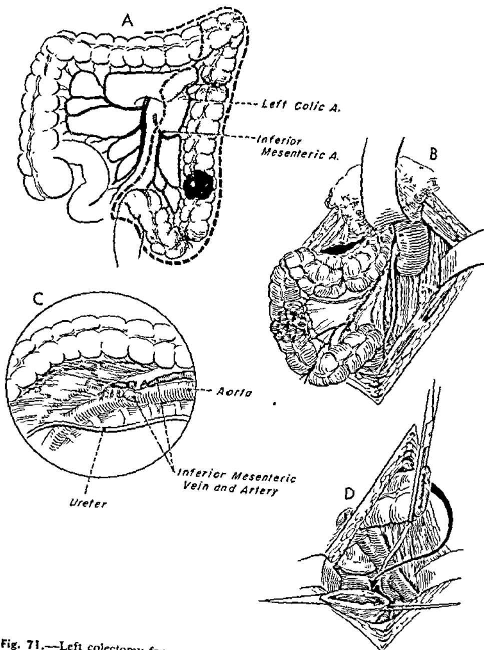
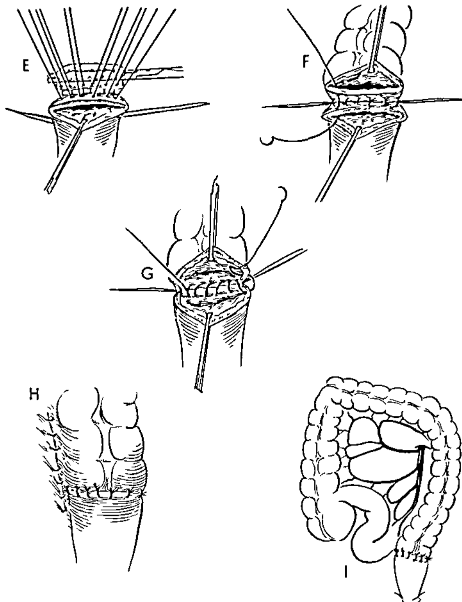


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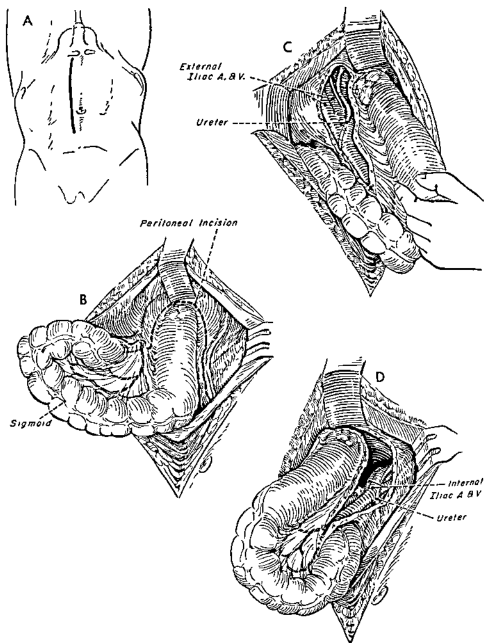


Fig. 72.—Combined abdominoperineal resection for cancer of rectum. **A**, left paramedian incision. **B**, sigmoid retracted upward; line of incision in peritoneum shown. **C**, left gutter opened; ureter and iliac vessels exposed; peritoneum divided on posterior inferior surface of bladder. **D**, sigmoid pulled to left; right ureter and iliac vessels exposed **(continued)**.

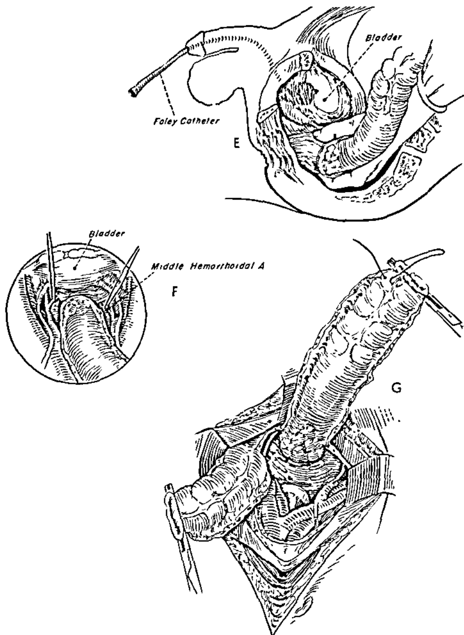


Fig. 72 (cont.).—**E**, by manual dissection, rectum is freed down to tip of coccyx posteriorly. **F**, ligation of middle hemorrhoidal vessels. **G**, sigmoid has been divided with cautery and distal end closed preparatory to being replaced below peritoneal floor **(continued)**.

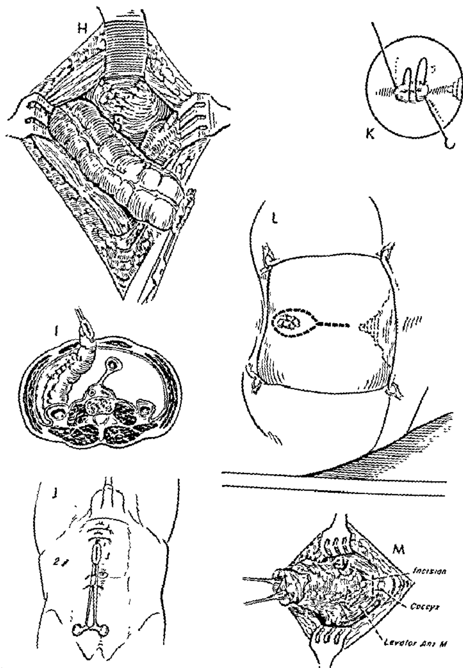


Fig. 72 (cont.).—**H,** peritoneal floor closed. **I,** closure of lateral trap shown in cross section. **J,** closure of abdominal incision. Mid-line *(1)* or left lower quadrant colostomy *(2)* optional, depending upon length of colon. **K,** perineal portion of operation begun; anus closed by purse-string sutures. **L,** line of incision extending up to coccyx; generous section of skin removed about anus. **M,** dissection carried down to levators; fascia propria of rectum opened just below coccyx. At this point, cavity formed by dissection from above is entered **(continued).**

colon include malignant lymphoma, leiomyosarcoma, fibrosarcoma, and melanocarcinoma. Carcinoids, while frequently benign, show evidence of extreme malignancy in about 10 to 15 per cent of cases in which the primary lesion is in the rectum or colon.

Benign tumors of the colon also may produce intestinal obstruction. They

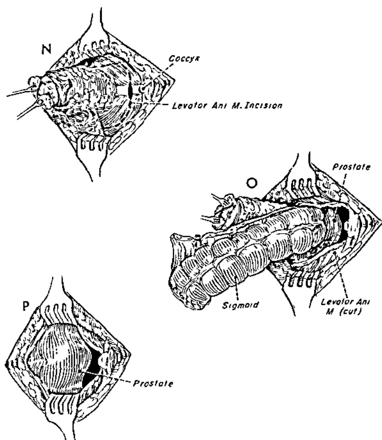


Fig. 72 (cont.).—**N**, levators divided near lateral wall of pelvis. **O**, upper end of rectum withdrawn; dissection continued anteriorly on prostate. **P**, completion of dissection.

include adenomas, lipomas, fibromas, angiomas, benign lymphomas, leiomyomas, and endometriomas. While nearly 10 per cent of the adult population harbor an adenoma, Bigelow and Anlyan found only 153 lipomas, the next most common benign tumor, described in the literature in 1949. Lipomas are somewhat commoner in the right or transverse than in the left colon. They originate from the submucosa and often initiate a colocolic

intussusception. Symptoms of recurrent intussusception may arise from large adenomatous polyps.

In the small intestine, a similar group of tumors is found, except that benign tumors are comparatively more frequent. Raiford, in a summary from the Johns Hopkins Hospital in 1932, found 88 malignant tumors of the small intestine, as compared with 50 that were benign. Of the malignant tumors, cancer is by far the commonest. Nearly half of those in the small bowel are located in the duodenum. At this level, jaundice is the most frequent early symptom, though the tumors later cause obstruction. Radical pancreatoduodenectomy has resulted in occasional five-year cures, and is the operation of choice.

Cancer of the jejunum or ileum produces obstruction early. Rapid metastasis to the mesenteric lymph nodes occurs. A radical node dissection generally is impossible because of the proximity of the superior mesenteric vessels, this fact accounting for the unfavorable prognosis of these tumors.

Malignant lymphoma, carcinoid, and leiomyosarcoma are other malignant tumors found in the small bowel.

An interesting feature of some carcinoid tumors may lead to their preoperative recognition. Particularly when the tumor is widespread, with hepatic metastases, the serotonin produced in argentaffin cells may produce a syndrome of intermittent attacks of flushing, cyanosis, dyspnea, abdominal pain, diarrhea, and occasionally pulmonary or tricuspid cyanosis. Duncan, Garven, and Gibbons have discussed the reported cases in a recent paper.

Benign tumors are most apt to produce obstruction by intussusception. Olson, Dockerty, and Gray found records of 77 small bowel tumors in the Mayo Clinic files. Thirty-eight of these produced symptoms. Of the 14 cases with evidence of obstruction, intussusception was demonstrated in 11 and compression of the intestine in three.

River, Silverstein, and Tope have prepared a comprehensive survey of the literature and have found 1,399 cases, exclusive of those seen in the Mayo Clinic. Obstruction was described as present in 877 cases and intermittent bleeding in 30.3 per cent of the total.

A clue to gastrointestinal polyposis is provided by oral pigmentation. According to Staley and Schwarz, 52 cases have been described since Jeghers re-emphasized this syndrome in 1949. Small bowel obstruction due to intussusception was noted in all but 5 cases. While cancer was present in the polyps in 9 cases, it was not invasive and no metastases or direct extensions have occurred. The location of the polyps was as follows: stomach-present 12, absent 40; jejuno-ileum, present 49, absent 3; colon, present 21, absent 31.

14

Obstruction Due to Injury

A. TRAUMATIC LESIONS

ABDOMINAL TRAUMA MAY PRODUCE intestinal obstruction by several means, including paralytic ileus, compression of the intestine by abscess or hematoma of the intestinal wall, and late traumatic stricture.

Paralytic ileus is by far the commonest type. Blood, either within the peritoneal cavity or in the retroperitoneal space, is notoriously apt to pro-

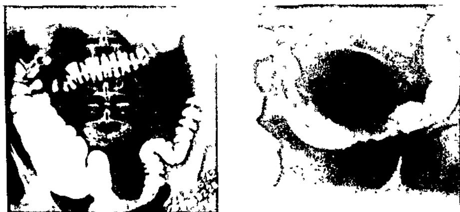


Fig. 73.—Radiation stricture of sigmoid. Note destruction of normal mucosal pattern on spot film.

duce severe ileus. Any complicating sepsis will make it worse. Consequently, prompt continued decompression by nasogastric suction is one of the essential details of treatment for any patient with a possible intra-abdominal injury or with retroperitoneal hematoma. While chest injuries often produce a severe paralytic ileus, care must be taken that the airway is not compromised by the necessary tube. Suction is continued until peristaltic activity is

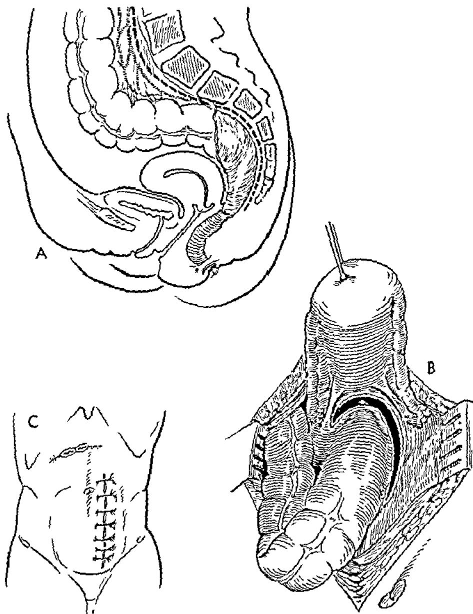
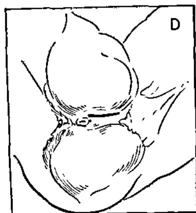
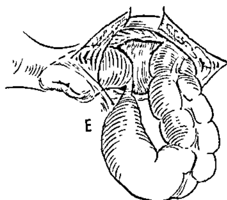
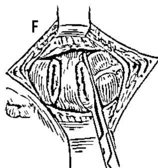
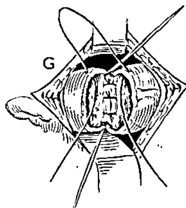


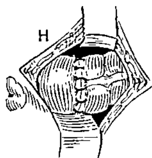
Fig. 74.—Resection of rectum and perineal anastomosis. This operation has been used by D'Allaine for cancer of rectum; here it is employed for postradiation stricture. Preliminary transverse colostomy had been done for relief of obstruction A, wide posterior mobilization of rectum down to levators carried out through abdominal incision. B, anterior mobilization of rectum. C, temporary closure of abdominal wall **(continued)**.











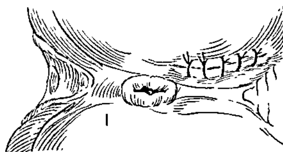


Fig. 74 (cont.).—**D,** perineal incision. **E,** rectum identified and mobilized and colon pulled down from above. **F,** stenosis resected. **G,** open end-to-end anastomosis begun. **H,** anastomosis completed. **I,** closure of perineal wound **(continued).**

resumed. Fractures of the lumbar spine also require careful prophylactic treatment.

A hematoma in the wall of the intestine itself may, by compression of the lumen, produce complete obstruction. Spencer, Bateman, and Horn found a total of 34 published cases of such lesions. A definite history of trauma was obtained in 22 of them. All parts of the gastrointestinal tract were involved

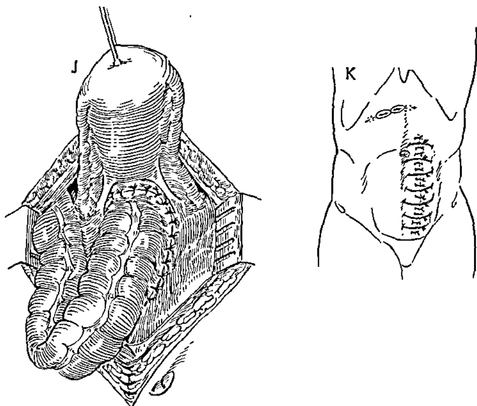


Fig. 74 (cont.).—*J*, abdomen is reopened and peritoneal floor closed about sigmoid. *K*, final closure of abdominal incision.

but half were in the duodenum. Simple evacuation or resection of the hematoma resulted in survival in every case so treated.

Later in the course of treatment of a patient with abdominal trauma, obstruction may result from adhesions or abscesses. If damage to the intestinal wall has been severe, a late traumatic stricture may form and culminate in acute obstruction.

B. RADIATION STRICTURES

After heavy pelvic radiation, stricture of the intestine or colon may result. The intraperitoneal rectum and the terminal 3 feet of ileum are affected

most commonly. Prior fixation of either of these viscera to the uterus by pelvic adhesions contributes to the probability of radiation damage. Wiley and Sugarbaker found evidence of radiation injury to the small intestine in nine of 600 irradiated patients; they usually were thin.

SYMPTOMS.—Symptoms usually are mild at first and are due to mucosal ulceration. Gross bleeding may be noted by rectum. Perforation of the devascularized loop may follow. At a later date, stenosis may occur and obstruction develop. Thus, complications may appear as late as 12 years after radiation (Fig. 73).

TREATMENT.—Stricture of the ileum is treated by resection and anastomosis. This operation will be complicated by several factors. The mesentery is apt to be thick and relatively avascular. Hence it is difficult to determine the proper segment of intestine that should be excised. Since healing of the anastomosis is likely to be poor, a generous section of ileum should be resected. It is better to turn in the distal ileum at the ileocecal valve and implant proximal ileum higher on the ascending colon than to carry out an anastomosis in edematous ileum.

Strictures of the rectum may be complicated by rectovaginal fistula as well as by rectal bleeding and obstruction. For obstruction, a transverse colostomy is necessary. If the patient is in good condition, a resection and anastomosis may be considered. This operation is rarely feasible and if attempted is done with some hazard, because the irradiated bowel heals with difficulty. A transverse colostomy should precede a resection (Fig 74).

15

Intussusception

INTUSSUSCEPTION REFERS TO THE invagination of one segment of intestine (the intussusceptum) into another (the intussuscipiens). It may occur at any age. Since small, temporary intussusceptions and retrograde intussusceptions occasionally are observed during fluoroscopic studies of the normal small intestine, it is probable that these processes are physiologic and only become pathologic when spontaneous reduction does not occur.

ETIOLOGY.—In the great majority of cases in children, the disease is idiopathic. Specific causes were found by Gross in only 6 per cent of his group. Hypertrophy of Peyer's patches, which are comparatively much larger in infants than in adults, may initiate the invagination in the idiopathic type; though this theory provides a possible cause, it has not been proved. A Meckel's diverticulum or tumor furnishes the leading point in most of the cases in children in whom a definite cause can be established; polyps, lymphomas, duplications, and prominent ileocecal valves are rare causes. Among adults, specific causes are present in 90 per cent of the patients. Unusual types of intussusception occur through gastroenterostomy or enteroenterostomy stomas.

PATHOLOGY.—Classified according to the location in the bowel, the common types are illustrated in Figure 75. Ileocolic intussusceptions are commonest in children, comprising 77 per cent of Gross's series. Ileoileocolic intussusception occurred in 12 per cent, jejunoileal or ileoileal in 5 per cent, colocolic in 2 per cent, multiple in 1 per cent, retrograde in 0.2 per cent, and type not stated in 3 per cent. In adults, the colocolic, ileocecal or ileocolic, and enteric types are about equally common. Multiple intussusceptions may occur simultaneously: as many as five have been observed in a single patient. Unless reduction occurs promptly, the intussusception becomes gangrenous, and it may, in exceptional cases, slough away and be discharged

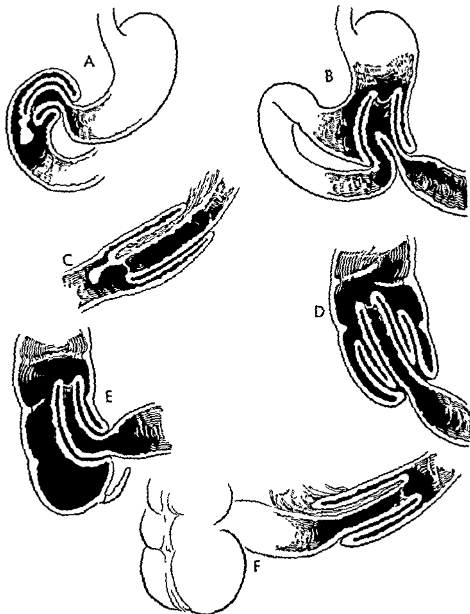


Fig. 75.—Types of intussusception. A, gastroduodenal, due to gastric polyp. B, jejunogastric (combined type). C, ileoileal, due to polyp. D, compound (ileoileocolic). E, ileocolic. F, retrograde.

through the rectum. Nature is rarely so kind, however, and the mortality rate of the disease rises sharply with delay in treatment.

A. INTUSSUSCEPTION IN CHILDREN

DIAGNOSIS.—In children, intussusception is about twice as common in boys as in girls (65 per cent to 35 per cent in the Boston Children's Hospital series). The peak incidence, according to Gross, is noted between the third and eleventh months of life, with 75 per cent of the cases appearing



Fig. 76.—Ileocolic intussusception. Man, 48, had ileocolic intussusception arising from submucous lipoma of ileum. A, note coil-spring appearance in cecum on filling by barium enema. B, on evacuation, intussusception is outlined clearly.

within the first year of life and 85 per cent within the first two years. According to Orloff's collective review of 1,814 cases, 80 per cent appeared within the first two years.

The diagnosis usually is easy because of the dramatic onset. Typically, in a healthy male infant, previously well, severe abdominal pain develops, followed by vomiting, a bloody stool, and a variable degree of shock. At the onset the child screams, draws up his legs to guard his abdomen, or assumes some unusual position, and he becomes pale and sweats with each attack of colic. Attacks appear every 10 to 15 minutes. Grunting respirations and crying accompany each attack. Between these episodes the child appears perfectly normal. Pain is followed shortly by repeated vomiting. Blood usually is not present in the first stool but occurs in the succeeding movements in

variable amounts, ranging from slight staining to severe hemorrhage. At this time a mass is usually palpable in the abdomen along the course of the colon or by rectal examination. Later the untreated child develops fever and prostration.

In a few instances, the disease is much less fulminant, and the diagnosis can be proved only by barium enema or laparotomy.

The incidence of the important signs and symptoms was noted by Gibson, Dockerty, and Dixon in 56 cases from the Mayo Clinic. Pain occurred in 94.6 per cent, vomiting in 80.3 per cent, bloody stools in 69.6 per cent, bloody enema returns in 9 per cent, and hematochezia either by history or on physical examination in 85.7 per cent. A mass was observed in 28.5 per cent.

X ray examination.—The diagnosis of any intussusception that has extruded into the colon is made readily with use of the barium enema. This method is essential in dubious cases; otherwise, except as a therapeutic *measure, it is unnecessary. If the barium enema is used, care must be taken* that the examination is conducted expeditiously, without harming the child by prolonged, rough maneuvers.

The scout film customarily shows dilated gas-filled intestine above the point of obstruction in late cases, but in early ones, only a soft-tissue mass may be visible. This will be the only sign in an ileoileal intussusception. When *the intussusception has progressed into the colon, a narrow cylinder of gas* may be demonstrated about it. A barium enema will show the intussusception surrounded by a thin layer of barium, which resembles a coiled spring or spiral sheath (Fig. 76).

The methods of diagnosis by X ray in adults have been described by Schatzki. Caution must be observed in the preliminary administration of barium by mouth; though it seems to delineate the intussusception well (Fig. 77), it may complicate the subsequent operation.

TREATMENT.—Numerous procedures have been employed for the surgical treatment of intussusception. Many are of historical interest only and will not be considered here, since they cannot be recommended. The only methods that are commonly used are reduction by the barium enema and operative reduction, supplemented by resection with immediate or delayed anastomosis for irreducible or gangrenous intussusception.

Reduction by barium enema.—This method has become more widely accepted. Hydrostatic pressure has been used widely in Scandinavia and in Australia for many years. Hipsley, in 1926, used saline solution, but this method was superseded by the barium enema, which provides both diagnosis and treatment.

Ravitch described the method and used it without mortality as the primary method of treatment in 65 cases. In 50, no further treatment was required.

He inserts a Foley catheter with a 40-cc. balloon into the rectum and straps the buttocks together. The barium container is elevated 3 feet above the table, and the barium must be seen to reflux well up the terminal ileum, or compound intussusceptions may not be reduced. If complete reduction is not



Fig. 77.—Intussusception of cancer of sigmoid. Intussusception, surrounded by cylinder of gas, is outlined clearly by inadvertent barium meal. Fortunately, obstruction was not complete and resection and primary anastomosis were carried out in one stage. Initiating lesion was polypoid cancer of descending colon.

possible, the child is taken immediately to the operating room, which had been alerted before the radiologic study was begun.

The earlier the diagnosis is made, the more likely is the chance of reduction by barium enema. This is probably the most important factor in accounting for its varying popularity in different centers. Apparently there is no danger that a gangrenous intussusception can be reduced by this method.

Some surgeons, such as Gross and Koop, believe that this method is unwise and dangerous. Others, such as Wangensteen, have found it ineffective.

In the Massachusetts General Hospital, interest in it has been rising, and there is every reason to believe that it will become increasingly popular. It is of particular value in those patients who appear early, those in whom the manifestations of the disease are not fulminant, and those in whom the diagnosis is in doubt.

The rigid criteria elaborated by Orloff can be recommended to obviate the hazards of hydrostatic pressure treatment. They are:

1. It should not be used in children more than 5 years of age, since a causative lesion is common after that age.
2. It should not be used in cases with symptoms of more than 24 hours' duration.
3. The roentgenologist should be experienced with the method.
4. The surgeon should be in attendance and the operating room readied during the procedure.
5. The pressure should not exceed 3 feet and no abdominal manipulation should be used.
6. The criteria of complete reduction should be followed completely. If any doubt exists, operation should be performed.
7. The patient should be observed carefully after the reduction; if symptoms occur operation should be done immediately. As a test, Ravitch has given charcoal or carmine by mouth; if the substance is recovered by a saline enema, reduction must have been complete.
8. No cases of recurrent intussusception should be treated by this method.

Operative treatment.—However, operation remains the safest and wisest method of therapy. A right paramedian incision is made regardless of the location of a palpable mass. The surgeon has the choice of reduction by manipulation or of resection. Manipulation will be successful in over 90 per cent of the cases. The surgeon milks the intussusception back through the distal colon by gentle pressure on the head of the tumor. As the cecum is reached, it must be delivered on the abdominal wall. A protracted period may be necessary in the terminal stage of the reduction. If the reduction has been easy and the patient is in good condition, there has been no hesitation at the Massachusetts General Hospital to do an appendectomy as well. On the other hand, the surgeon must remember that his primary duty is to reduce the intussusception, not to remove the appendix; the additional procedure could prove fatal in a very ill child (Fig. 78).

Resection is necessary when the intussusception cannot be reduced or the intestine has been badly damaged by the manipulation. Gross considers it advisable, also, when the child is acutely ill, since all necrotic material is thus removed immediately from the body.

Resection and immediate end-to-end anastomosis is now the most popular procedure and is the method of choice in our hospital, though until recent years it carried a high mortality. Wangensteen reported 19 cases with one

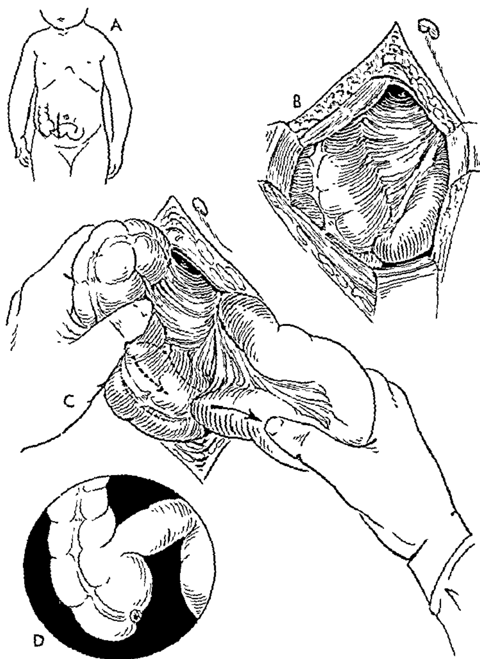


Fig. 78.—Treatment of intussusception. **A**, right rectus incision. **B**, intussusception exposed. **C**, intussusception reduced by gentle pressure with fingers of left hand. Cecum is lifted out of peritoneal cavity to complete reduction. **D**, reduction has been easily effected. Appendectomy has been done **(continued)**.

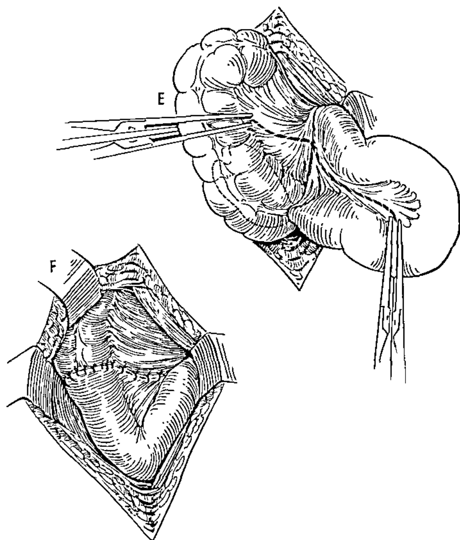


Fig. 78 (cont.).—E, complete reduction is impossible. Resection and end-to-end anastomosis are preferred. Ileum and colon are divided between clamps. **F,** end-to-end anastomosis has been completed.

death and Benson 13 with one death. Lawrence and Ulfelder reported on 18 patients who had resection and primary anastomosis at the Massachusetts General Hospital; of the five children one died, and of 12 adults one died. Gross still believes that the Mikulicz procedure is the safest; he performed 18 such resections, with three deaths. If a Mikulicz operation is to be done, it is important that the secondary operation be carried out promptly. The spur is out in two to three days and the fistula closed in a week.

PROGNOSTIC FACTORS.—It long has been recognized that early operation is the most important factor leading to success and that variations in delay before treatment account for differences in most series of reported statistics. Among 110 patients operated on within 24 hours in the Children's Hospital from 1928 through 1939, there was no mortality. From 1948 through 1950, 92 consecutive patients were treated without a fatality.

The important prognostic factors, according to Kahle and Thompson, include, besides delay in treatment, the ability to reduce the intussusception and the admission temperature. Their patients with a delay of none to 12 hours had no mortality, as contrasted with a 66.7 per cent mortality when the delay was 72 to 96 hours. Reducible intussusceptions had a mortality of 18.3 per cent, and irreducible of 42.8 per cent. Children with temperatures of 102 F. had a 66 per cent mortality, and those whose temperature was under 100 F., a 10 per cent mortality.

RECURRENT INTUSSUSCEPTION

While recurrent attacks of idiopathic intussusception occur, their incidence is low, amounting to only 2 per cent in the Children's Hospital series. Several operative measures have been devised to prevent a recurrence; the one that has been used most frequently is application of the proximal ileum to the cecum. In view of the rarity of recurrence, there seems little point in doing this at the time of the original attack. Gross noted that when repeated attacks had occurred, there usually was a prominent lip of redundant mucosa at the ileocecal valve, so he advises a resection of the terminal ileum and cecum.

B. INTUSSUSCEPTION IN ADULTS

It has been estimated that about five per cent of all intussusceptions occur in adults. Donhauser and Kelly collected 665 cases reported in the American and English literature between 1900 and 1947. Eighty more were collected by Brayton and Norris from 1947 to 1954. The disease varies significantly from that observed in childhood. There is nearly always an etiologic agent, the manifestations of the disease are unlikely to be dramatic, and surgical treatment is always necessary (Fig. 79).

Dean, Ellis, and Sauer reviewed 96 cases that had been observed in the Mayo Clinic. The site of the intussusception was as follows: enteric 30.2 per cent, ileocecal or ileocolic 36.5 per cent, and colocolic 33.3 per cent. Malignant tumors accounted for 60.4 per cent, benign tumors for 17.7 per cent, and Meckel's diverticula for 4.2 per cent. Various other organic causes were found in 5.2 per cent of cases, while the idiopathic type was encountered in



Fig. 79.—Carcinoma of colon with intussusception. Carcinoma of colon is observed rarely in living patient except through sigmoidoscope or on operating table. This cancer which has intussuscepted through anus, arose from transverse colon. (Courtesy of Dr. A. W. Allen.)

only 12.5 per cent. Enteric intussusception, while usually due to Meckel's diverticulum or benign tumor, may follow any type of obstruction, including that by an intestinal tube balloon.

The symptoms in adults tend to be mild and repetitive. The radiologist may note intussusception in association with a tumor of the colon when the patient is having no symptoms or only mild cramps. A long history is most suggestive of a benign tumor, of which a lipoma is the commonest. A palpable mass and gross rectal bleeding are relatively uncommon. Acute obstruction was encountered in only 13.5 per cent of the Mayo Clinic series.

Because of the high incidence of initiating causes, surgery is always necessary when intussusception is encountered in an adult. This usually consists of a resection of the involved area and the underlying lesion. A careful search must be made before the disease is said to be of the idiopathic type in an adult.

C. RARE TYPES OF INTUSSUSCEPTIONS

Gastroduodenal intussusception is manifested by severe epigastric pain and gastrointestinal hemorrhage. The barium meal will show a filling defect in an enlarged duodenum and distention of the stomach. The usual cause is a benign gastric tumor; intussusception due to a prolapsing cancer is rare. Forty-one reports of this syndrome were collected by Hobbs and Cohen in 1945; seven others were summarized by Child and Braunstein.

Jejunogastric intussusception is a rare postoperative complication following operation on the stomach involving anastomosis to the jejunum.

Intussusception of the appendix occurs rarely. The appendiceal stump, either inverted or noninverted, or cecal haustra also may induce unusual invaginations.

16

Obstruction from Rare Causes

A. ENDOMETRIOSIS

THOUGH ENDOMETRIOSIS IS A COMMON LESION and frequently involves the rectum or colon, it is a rare cause of intestinal obstruction. For example, Kratzer and Salvati found in a study of 225 cases of endometriosis that 34 per cent involved the bowel. Implants or endometrial adhesions were present in nearly all of the cases. Four patients had endometriomas of the sigmoid that grossly resembled carcinoma, but only two had signs of partial intestinal obstruction. A collective review of the literature indicated that about 90 endometriomas had been reported with some degree of intestinal obstruction. Cattell and Colcock and Lamphier described 26 cases from the Lahey Clinic; McGuff, Dockerty, Waugh, and Randall, 16 from the Mayo Clinic, and Jenkinson and Brown, 21 cases.

Endometriosis producing obstruction in the sigmoid occurred in 13 of the 16 Mayo Clinic cases, while the three other obstructions were in the terminal ileum. The obstruction of the colon was due to annular constriction in three cases, submucosal proliferation and luminal obstruction in eight, and infiltration with angulation of the sigmoid in two.

The disease with which a sigmoid endometrioma is most often confused is cancer. The differential diagnosis, therefore, is important. Obstruction due to endometriosis nearly always occurs before the menopause, but it may occur afterward owing to contraction of the fibrous stoma. Constipation is worse at the time of periods and usually is noted for a long time before the acute obstruction occurs. The other stigmata of endometriosis, such as infertility, dysmenorrhea, and the usual findings at pelvic examination, including fixed retroversion of the uterus, fibroids, masses in the vaults, and nodules in the rectovaginal septum, are common. The barium enema usually shows a filling defect with intact mucosa, but the condition may simulate



Fig. 80.—Obstructing endometriosis of ileum. Woman, 39, single, had severe abdominal cramps and vomiting of 12 hours' duration. Operative specimen includes section of terminal ileum obstructed by endometriosis, uterus, tubes, ovaries, and appendix, all of which were involved.



Fig. 81.—Endometriosis of sigmoid. **Left,** sharply localized defect in mid-sigmoid. **Right,** spot film showing essentially normal mucosal pattern.

cancer very closely, especially when the obstruction is severe (Fig. 81).

TREATMENT.—The type of therapy must depend on several factors. Complete obstruction of either intestine or colon will require resection. Partial obstruction of the sigmoid may be expected to relent after bilateral salpingo-oophorectomy, which preferably is combined with total hysterectomy. If the patient is young and desires to have children, resection of the sigmoid is preferable to castration. Castration by radiation therapy has produced relief of subacute obstruction in certain instances and in some cases will be the preferred treatment.

It must be noted that pelvic endometriosis and carcinoma of the sigmoid may occur in the same patient; great care must be taken, therefore, to exclude malignant disease if any type of conservative therapy is to be followed. Endometriosis may also obstruct the ileum (Fig. 80).

B. PNEUMATOSIS

Pneumatosis cystoides intestinalis is a rare lesion in which multiple gas-filled cysts form within the lymphatics of the intestine or colon. There may be spontaneous regression, or the disease may advance, producing obstruction of the gut. Pneumoperitoneum may follow because of perforation. The cause is not always evident, though, in the stomach pneumatosis is sometimes associated with benign ulceration or pyloric obstruction.

The origin of the cysts in the gut in most instances is explained by gas escaping into lymphatic channels from a mucosal break just proximal to a point of obstruction. Kukral, Plank, and Denst noted that intestinal obstruction is the principal complication of pneumatosis. The various mechanisms involved include obstruction of the intestinal lumen by submucosal cysts, volvulus induced by cysts, compression of intestine by extensive masses of cysts or from adhesions engendered by cysts, and multiple intrinsic strictures associated with cysts (Fig. 82).

X ray examination is often diagnostic. The features have been discussed by Gazin, Brooke, Lerner, and Price. Pneumoperitoneum may be demonstrated. Finely reticulated gas-filled cysts can be outlined along the walls of the intestine, outside of the lumen. A loop of intestine may be visualized above the liver. If there are cysts in the low sigmoid, they can sometimes be seen as white, elevated nodules; a biopsy of a nodule may show multiple giant cells surrounding a cyst wall.

TREATMENT.—Occasionally the disease is encountered at laparotomy for some other cause and is not extensive. Such cases usually subside spontaneously. A large mass of cysts that is sharply localized or extensive pneu-

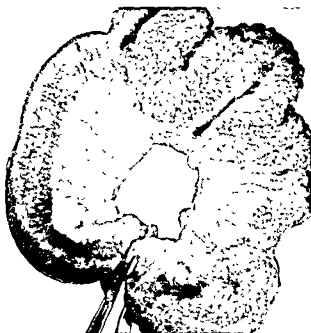


Fig. 82.—Pneumatosis.

matosis encountered with some obstructive lesion should be treated surgically. Resection of the involved segment is best, though short-circuiting operations about an obstruction have been successful.

17

Obturation Obstruction

Obstruction by obturation refers to the obstruction of an otherwise normal intestine by an object such as a foreign body that is attempting to pass down the bowel. A somewhat similar situation occurs when underlying disease produces a narrow tract, which is completely obstructed by material that can be excreted easily by the normal bowel. For example, a partial obstruction due to diverticulitis may be converted to a complete one by the formation of an enterolith after injudicious administration of barium by mouth.

Whatever the cause of this type of obstruction, it is most apt to manifest itself in the narrowest portions of the intestinal tract. The colon, therefore, is rarely obstructed except in the sigmoid, while all kinds of obturation obstruction except that due to fecal impaction are commoner in the small intestine.

The causes of obturation obstruction include gallstones, bezoars, foreign bodies, worms, enteroliths, fecal impaction, meconium ileus, and inflated balloons of intestinal tubes. Obturation ileus always is simple in type, but, as time progresses, pressure necrosis occurs and perforation of the gut ensues.

A. GALLSTONES

Clinical features.—McLaughlin and Raines, in 1951, collected data on 19,692 intestinal obstructions from the literature and found that the incidence of gallstone ileus was 1.9 per cent. This figure corresponds almost exactly to that obtained by Balch in 1938 at the Massachusetts General Hospital, where the incidence was 2 per cent. Recently, however, gallstone obstruction has become less common, since cholecystectomy now is being done much more frequently before this serious complication occurs. At the present time gallstone ileus comprises only 0.8 per cent of the acute obstructions seen in the Massachusetts General Hospital.

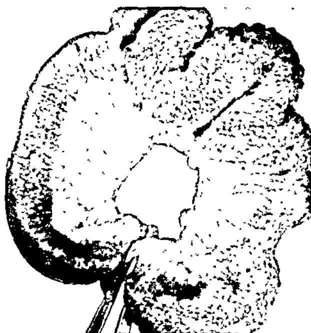


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The disease usually occurs in elderly, obese women, many of whom have other complicating illnesses, such as heart disease or diabetes. A past history of gallbladder disease can be obtained in about half of the cases. The condition is three times as frequent in women as in men. Though it is most commonly found in the elderly, Wartmann has observed it in a woman 25 years of age.

The symptoms vary, depending upon the method by which the stone passes into the intestinal tract. A fistula usually forms between the gallbladder and the duodenum. Less commonly, perforation occurs from gallbladder into stomach or colon or from common duct into duodenum. In one instance, cited by Murphy, the stone apparently passed through a hugely dilated common duct and was large enough to obstruct the intestine later. In one case in the Massachusetts General Hospital, the stone was nearly 5 inches in diameter and was so large it eroded the wall of the duodenum, blocking it by direct pressure, but could not enter the bowel.

In the instances in which perforation occurs into the stomach, pyloric obstruction may develop or the patient may vomit the smaller stones. When the perforation is into the colon the stones are usually passed by rectum without production of obstructive symptoms, though they may obstruct the sigmoid. When perforation occurs into the duodenum, as it usually does, the stone may be halted at any narrow spot in the intestine on its downward migration. The commonest sites of obstruction in order of frequency are the ileum, colon (either descending or sigmoid), duodenum, and jejunum. The stone also may be caught by a Meckel's diverticulum or above any adhesions. Courvoisier noted that the calculus was impacted in the duodenum or jejunum in 21.4 per cent of cases, in the ileum in 65.4 per cent, in the ileocecal valve in 11 per cent, and in the sigmoid in 2.4 per cent. The descent of the stone from one narrow spot to another may be punctuated by intermittent attacks of colic. Holm-Nilsen and Linnet Jepsen collected 26 cases of obstruction of the colon due to gallstones, accounting for 3 to 5 per cent of all cases of gallstone ileus. In several instances the obstruction occurred in normal bowel.

There is usually a long delay between onset of symptoms and the patient's hospital admission, which undoubtedly contributes to the continued high mortality. That the stone may remain latent in the intestine for a protracted period was shown by Warner and Swan, who removed a gallstone that was obstructing the ileum two and one-half years after a cholecystectomy.

Obstructing stones may be single or multiple, as emphasized by Hinchey. The presence of facets on an obstructing stone indicates that at least one other stone exists, which may produce obstruction at a later date unless it

is found. Many instances of recurrent obstruction from stones have been reported in the surgical literature.

The size of a stone that will produce obstruction is of great interest. Travers observed a fatal obstruction from a stone that weighed only 4 Gm. However, such stones are usually 2.5 cm. or more in diameter. An element of spasm must attend the presence of the stone and complete a partial mechanical obstruction.

SYMPTOMS.—The symptoms are those of small-intestinal (or rarely colon) *obstruction. In addition, the patient may give a history of vomiting a stone* or of passing one by rectum. A history that is definite or suggestive of gallbladder disease usually can be obtained, and occasionally there still will be tenderness in the right upper quadrant because of acute cholecystitis. The remainder of the abdominal cavity is free of tenderness, however, unless pressure necrosis of the intestine occurs or a volvulus of a distended loop results above a fixed impacted stone.

The X ray examination is extremely important because it may demonstrate the stone or show a fistula to some part of the biliary tract (Fig. 83). The frequency with which a stone can be identified by the radiologist is hard to determine; it is seen in about half of the cases in the Massachusetts General Hospital and frequently recognized in many other cases after the correct diagnosis has been made by surgery. If a stone is seen, the exact size may not be indicated, since only an opaque center may be visible and it may be surrounded by a large nonopaque section.

In cases in which gallstone ileus is suspected, spot films should be centered on the liver. If air is observed in the biliary tree the presumptive diagnosis can be made. This finding is nearly constant. Administration of a little thin barium by mouth may suffice to make the diagnosis either by outlining the fistula to the biliary tree or by showing the stone. Providing that it introduces no significant delay, this is a safe procedure.

TREATMENT.—The essentials of treatment include the removal of the stone by enterotomy, a search for any other stones, and neglect of the cholecystoduodenal fistula (Fig. 84).

Operation is carried out as soon as feasible. An attempt to wait for spontaneous passage of a stone that has already produced obstructive symptoms introduces additional delay and is not recommended. After location of the stone it should be pushed proximally if possible so that the enterotomy can be carried out in more normal intestine. Since there usually is great distention of the proximal bowel, care must be taken to avoid spilling any intestinal contents. Use of rubber-covered intestinal clamps or aspiration of the intestine is essential. The intestine is opened over the stone, the stone extracted, and the opening closed with two layers of sutures.

When the stone cannot be displaced, incision must be made directly at the site of impaction. If a large gangrenous area is present, resection with primary anastomosis is preferable. The removed stone must be examined, since the presence of any facets make it necessary to palpate the remainder of the small intestine to be certain that no others are present.



Fig. 83.—Gallstone obstruction. Woman, 67, complained of abdominal pain of four months' and vomiting of three days' duration. Since she was believed to have a cancer of stomach, a gastrointestinal series was made. Note dilated loops of jejunum extending down to obstructing gallstone and barium in biliary tree. At operation, gallstone was found in ileum.

Any attempts to solve the problem of the cholecystoduodenal fistula at the time of operation for obstruction are meddlesome and dangerous. It is surprising to find out how well nature heals this lesion and how rarely fistulization is followed by recurrent symptoms of gallbladder disease that require a later operative attack. If it is known, however, that stones still are present in the gallbladder, or if recurrent symptoms appear, a subsequent cholecystectomy and excision of the fistula are necessary.

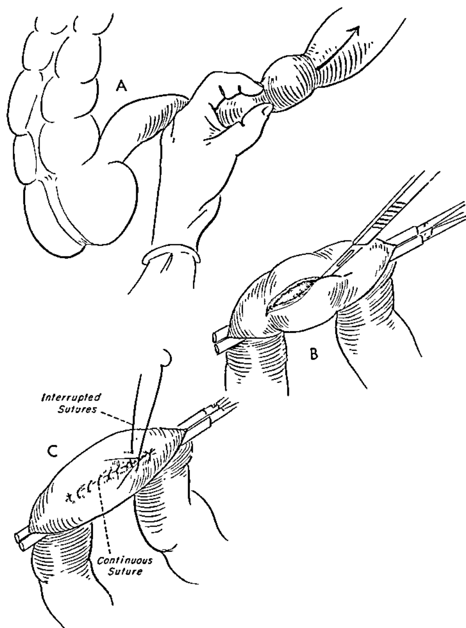


Fig. 84.—Enterotomy for gallstone. **A,** if possible, obstructing stone is pushed proximally into normal bowel. **B,** rubber-covered clamp is advisable if intestine has not been completely deflated. Longitudinal incision is made and stone extracted. **C,** enterotomy incision is closed in two layers.

MORTALITY.—The mortality of gallstone ileus has been particularly high. McLaughlin and Raines collected reports on 502 patients treated between 1890 and 1940; the over-all mortality was 52 per cent. There has since been a significant reduction in the rate. Nemir reported one fatality in eight cases, McLaughlin none in five, Wangensteen three in 12 operations, and Deckoff one in 14 cases. The four patients in the present Massachusetts General Hospital series and four seen since have all survived.

B. BEZOARS AND FOOD BOLI

Bezoars are solid concretions formed by collections of foreign or intrinsic substances found in the stomach and intestines. They are of great interest, not only because of their pathologic significance, but because they have in the past been highly prized as remedies for nearly all known lesions. They may consist of a variety of materials but usually are classified as trichobezoars (hair balls), phytobezoars (vegetable bezoars), and concretions of other origin. They are comparatively rare, but De Bakey and Ochsner collected 311 cases in 1938.

Food boli, on the other hand, consist of amorphous conglomerates of undigested foods at some point of the gastrointestinal tract. They are commoner and have a tendency to increase in number during periods of starvation when there has been a high intake of cellulose-containing food.

Trichobezoars consist of masses of hair firmly matted together in one or more balls. As a rule they finally assume the form of the stomach and may attain enormous proportions. Frequently they extend into the duodenum, and in many recorded instances masses of hair have broken off and have lodged in the lower small intestine, producing acute obstruction. De Bakey and Ochsner collected 172 cases in 10.8 per cent of which there was intestinal obstruction with a mortality of 47 per cent.

The disease occurs in neurotic women who swallow their own hair. It is usually diagnosed by the presence of a firm, painless epigastric tumor conforming to the shape of the stomach. Oral administration of barium produces a typical picture.

The treatment consists of gastrectomy and removal of the bezoar. If the lower ileum is obstructed, the hair ball is evacuated through an enterotomy incision.

Phytobezoars may be composed of a great variety of vegetable substances. The commonest, due to persimmons, accounted for 75 per cent of all De Bakey and Ochsner's 126 collected cases. Persimmon bezoars are much more likely to be found in the stomach than in the small intestine, though about one-fifth have been found in the jejunum or ileum. Other substances

that have formed true bezoars include cocoanut fibers, string, celery fibers, pumpkin fibers, roots, figs, grape skins and stems, prunes, raisins, leeks, mallow, and wild beets. Intestinal obstruction occurred in 26.5 per cent of DeBakey and Ochsner's cases, with a mortality of 16 per cent.

Other concretions that form in the stomach or intestine may be produced after the ingestion of shellac or medications such as bismuth carbonate, aluminum hydroxide, and bulk-producing substances designed to relieve constipation.

Food boli may produce obstruction of either the small intestine or the colon. A large number of substances have been described. Ward-McQuaid listed 45 types of food which had caused obstruction. These included orange peel or pulp, peaches, apricots, beans, potatoes, mushrooms, corn, bran, oats, sauerkraut, poppy-seeds, bones, fruit stones, peanuts, apples, beets, and carrots. The list is one that will not please a vegetarian. Plum pudding, regrettably, must be added to the list. In our experience obstruction from these boli has been commoner after subtotal gastrectomy than in the normal intestinal tract. Poor mastication of food and painful, ill-fitting dental plates also are important predisposing causes.

The treatment of complete obstruction due to any of these substances is enterotomy. At times the type of obstruction can be recognized by the history, and if it is subacute, it can be treated by a liquid diet and cathartics.

C. FOREIGN BODIES

It is amazing to discover how many foreign bodies will pass through the intestine or occasionally rest there for years without producing intestinal obstruction. Gross studied the fate of 766 foreign bodies swallowed by infants and children. About 20 per cent had to be removed from the esophagus. Only 7 per cent of the patients in whom the foreign body entered the stomach had to have a laparotomy performed. Apparently nearly all rigid objects that could get into the stomach eventually were passed through the gastrointestinal tract. When sharp objects persisted in one position for several days, as checked by X ray, operation was carried out because of the chances of late perforation. Operation was necessary later in only six patients in whom the foreign body passed into the upper jejunum.

Acute intestinal obstruction due to swallowed foreign bodies, therefore, is rare in normal persons. On the other hand, psychopathic patients may swallow a multitude of foreign bodies that produce obstruction. They include pieces of metal, glass, bones, nails, and screws. Murphy buttons have lodged at the ileocecal valve or in the sigmoid and have led to obstruction.

The treatment is enterotomy or colotomy with extraction of the foreign body.

D. ENTEROLITHS

Enteroliths are uncommon in the human intestinal tract except in the appendix and in a Meckel's diverticulum. They usually consist of a small central calculus, such as a foreign body, fruit, seeds, or a gallstone, about which intestinal contents have been deposited. They are most likely to form above strictures or just proximal to the ileocecal valve. They also may follow the

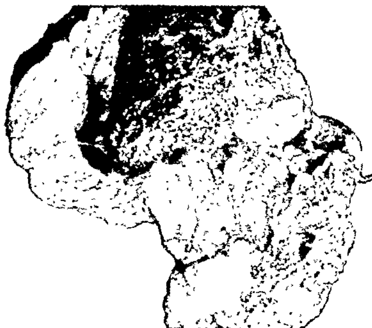


Fig. 85.—Enterolith, 5 cm. in diameter, found in distal sigmoid loop after loop colostomy. Severe diarrhea developed, apparently owing to reflex. Patient was cured by resetion of colostomy and fecalith-containing section of bowel, with restoration of intestinal continuity.

ingestion of barium or colloidal suspensions used for the treatment of ulcer. Some of these concretions are extremely hard and large and may lead to perforation of the intestine or sigmoid and death. Such a type of constipation requires relief by colotomy rather than by enemas (Fig. 85).

E. FECAL IMPACTION

Fecal impaction may be a serious cause of obstruction. When it occurs in the rectum, digital extraction is effective, though occasionally full anesthesia is necessary. When impaction occurs at a higher level, it is usually due to some underlying disease of the bowel, such as diverticulitis, or to the administration of a large amount of barium by mouth to an ill patient. Five

patients have died from fecal impaction in the recent series of cases studied in the Massachusetts General Hospital. Two deaths were due directly to perforation of the colon from a barium fecalith. In the other patients, in terminal stages of other diseases, severe distention developed just before death from fecal impaction and required cecostomy or colostomy.

F. WORMS

Ascaris is the usual worm that produces intestinal obstruction in humans, though obstruction secondary to the fish tapeworm has been observed by

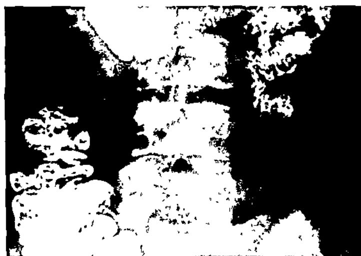


Fig. 86.—Ascaris in small intestine. Thirteen-year-old white girl had had epigastric burning, nausea, and occasional vomiting for seven months. Ascaris eggs were found in stool. Symptoms disappeared after vermifuge. Note worms outlined by barium.

Viikari. Children under 10 years of age are most commonly affected, and the lower ileum is the section of gut most frequently involved.

Manifestations of the disease may be either acute or chronic. The diagnosis rests upon the demonstration of ova in the stool, the production of worms by rectum after a vermifuge, or delineation of the worms on the X ray plate after oral administration of barium (Fig. 86). After a period of starvation, worms swallow barium, so their outlines can be observed as the barium meal passes down into the colon. Obstruction usually is due to obturation but also may be due to intussusception, spasm, or volvulus.

The usual treatment of acute intestinal obstruction secondary to ascaris usually has been enterotomy with removal of the clump of worms. This is a difficult, far from aseptic, procedure and may cause trouble postoperatively because worms tend to migrate through suture lines.

For these reasons, Aiken and Dickman prefer, if possible, to control distention by intubation, administering piperazine citrate by the tube to kill the worms. They recommend, from their experience with 10 cases, in acute obstruction, resection of the obstructed intestine with its mass of worms, leaving double enterostomies to be closed later.

G. MECONIUM

1. Ileus

Meconium ileus is a type of obturation obstruction observed in infants.

Etiology.—The condition is one manifestation of the disease mucoviscoidosis. This is characterized by a thickened, sticky, dimished secretion of mucous glands in alimentary and respiratory tracts, fibrocystic disease of the pancreas, a deficiency of trypsin in the pancreatic secretion, and a diminution and thickening of bronchial secretions leading to pneumonia. Owing to the lack of trypsin, the intestinal contents become thick and sticky. They block and dilate the lower ileum. The colon remains empty. Prenatal perforation of the ileum may occur, with production of meconium peritonitis.

Diagnosis.—Nausea and vomiting usually occur within the first few days of life. One or more masses of fecal matter often can be palpated through the abdominal wall. X ray examination may show many tiny gas bubbles scattered throughout thick masses of meconium as well as multiple dilated intestinal loops of varying size. The stool contains epithelial cells, and the vomitus, as noted by lack of digestion of an exposed X ray film, no trypsin. If operation is not carried out, perforation of the intestine occurs and the signs of peritonitis appear.

Treatment.—Mild forms of the disease may be treated conservatively by enemas and pancreatin. Most infants, however, will need operation. Hiatt and Wilson reported success with saline irrigations of the intestine through an enterotomy incision, but this usually is not possible. Gross believes that the best treatment for the disease is exteriorization and excision of the distended segment of intestine, which usually is the terminal ileum. The ileostomy stoma usually is closed three weeks later.

Bishop and Koop have recently reported the use of a Roux-Y anastomosis of the distal ileum, bringing out a single barrel for irrigation with pancreatic enzymes.

The patient is treated with pancreatin but may succumb later from pancreatic insufficiency. Though formerly the disease nearly always was fatal, since 1949 Gross has had 19 cases, with recovery in 15, in which his method was used. Improvement was due to supportive care, avoiding of pulmonary complications by antibiotics, maintaining of adequate nutrition by a caloric intake one and one-half times normal, and administration of pancreatin.

2. Peritonitis

Meconium reaches the ileocolic junction at the fourth month of intrauterine life. It is toxic, and when introduced into the peritoneal cavity produces a chemical peritonitis. Meconium does not contain bacteria until the third day of extrauterine life. Meconium peritonitis may occur at any time after meconium is first formed until the early neonatal period. It is not necessarily fatal if it occurs before bacteria have entered the intestinal tract but is regularly fatal thereafter unless relieved by surgery.

Intestinal obstruction causes about 50 per cent of the cases of meconium peritonitis according to Low, Cooper, and Cosby. The obstruction may be due to meconium ileus, atresia, stenosis, adhesions, volvulus, or intussusception. Trauma is presumed to account for most of the remaining cases, though in some no cause can be established.

The diagnosis is suggested by severe distention noted at or soon after birth, persistent vomiting, cyanosis, and obstipation. The X ray will show multiple fine areas of calcification on the peritoneal cavity (as first demonstrated by Neuhauser), pneumoperitoneum, and dilated loops of intestine.

Prompt surgery may result in recovery. If meconium ileus is present, this must be dealt with as described above. Other associated causes of obstruction must be corrected. If no cause can be demonstrated, the site of perforation must be closed by suture. Bendel and Michel were able to collect from the literature eight recoveries following surgery and added one of their own.

H. INTESTINAL-TUBE BALLOONS

Obstructions due to balloons of intestinal tubes may produce complete intestinal obstruction if aspiration of air is prevented by too tight a tie on the balloon. At operation, the balloon may be punctured by a hypodermic needle through the wall of the intestine and the tube withdrawn.

18

Volvulus

A VOLVULUS IS A TWIST OF A VISCUS upon its mesentery of a degree sufficient to occlude partially or completely the blood vessels contained therein. Minor degrees of torsion occur frequently, but a twist of at least 180° is necessary to endanger blood supply. The term "primary volvulus" is restricted to the type of pathology in which there is no other cause of obstruction. Volvulus also may be secondary to other conditions, such as malrotations, adhesions, operative stomas, and foreign bodies.

Volvulus may occur in any portion of the gastrointestinal tract but appears chiefly in those portions of the bowel that have a long mobile mesentery. Abnormal fixation of the intestine may provide a fixed point about which torsion of a mobile segment of bowel may occur. Two long parallel limbs of a loop of gut that are closely attached near the base of the loop are particularly apt to twist. The disease is commoner in patients with megacolon, particularly when the colon is distended by feces.

The disease is variable in its symptoms and frequency according to the age and nationality of the patients. In the United States it causes about 5 per cent of all intestinal obstruction and is more frequent in infants and in the aged. In eastern Europe the figure may run as high as 40 per cent, according to a summary by Gerwig, because of the greater incidence of megacolon and the predominantly vegetarian diet. Bruusgaard, reporting from Oslo in 1947, indicated that volvulus arose in the colon in 65 to 75 per cent of the cases, and that in nearly 90 per cent of the cases of colonic volvulus, the sigmoid was involved. Sweet, in 1930, found 53 cases of volvulus among 520 cases of obstruction in the Massachusetts General Hospital. Sixth-eight per cent were in the small intestine, 19 per cent in the sigmoid, and 13 per cent in the cecum. Wangensteen encountered 42 patients with primary and 22 with secondary volvulus in 1,252 cases—an incidence of 3.5 per cent for primary volvulus. In the Massachusetts General Hospital, at the present

time, primary volvulus accounts for 1.6 per cent of all obstructions and secondary volvulus for 1.7 per cent.

Since primary volvulus varies considerably in its manifestations accord-



Fig. 87.—Volvulus of stomach. A, pyloric end of stomach has rotated superiorly. B, after reduction, which occurred spontaneously. At operation, done soon after plate *B* was taken, evidence of recent volvulus was found. Gastropexy was done.

ing to its location, further discussion will be on the basis of the anatomic segment involved. Secondary volvulus is considered in the descriptions of the primary causes.

A. STOMACH

Volvulus of the stomach is a rare disease, since the stomach usually is attached firmly in the abdomen. However, 150 cases were collected by Dalgaard. It is most likely to be seen in association with a large paraesophageal hiatus hernia, in which case the symptoms of gastric obstruction may arise from either incarceration or volvulus. Severe epigastric or left chest pain and vomiting are the usual symptoms. Very rarely perforation occurs (Fig. 87).

Anatomically, two types are described (Fig. 88). In volvulus organoaxialis, the axis of rotation may be either anterior or posterior, but in the commoner form, the greater curvature rotates upward, so that the posterior surface of the stomach comes to lie aneriorly.

In the less common type, volvulus mesenterioaxialis, the stomach twists on

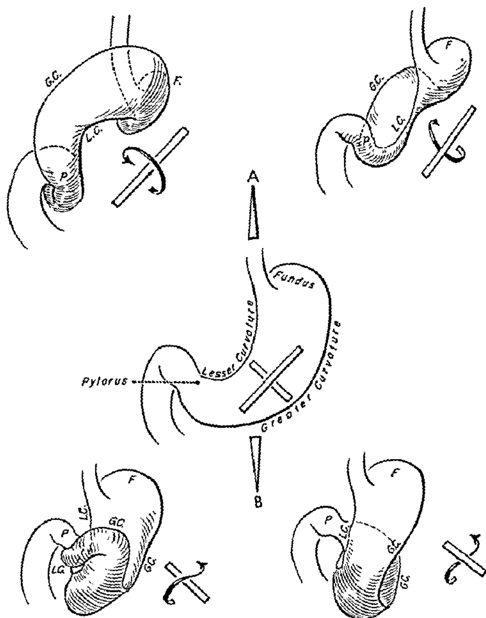


Fig. 88.—Types of volvulus of stomach. A, volvulus organoaxialis. On the left, greater curvature has rotated anteriorly; on the right, greater curvature is posterior. B, volvulus mesenterioaxialis. On the left, pylorus has rotated anteriorly; on the right, it has rotated posteriorly.

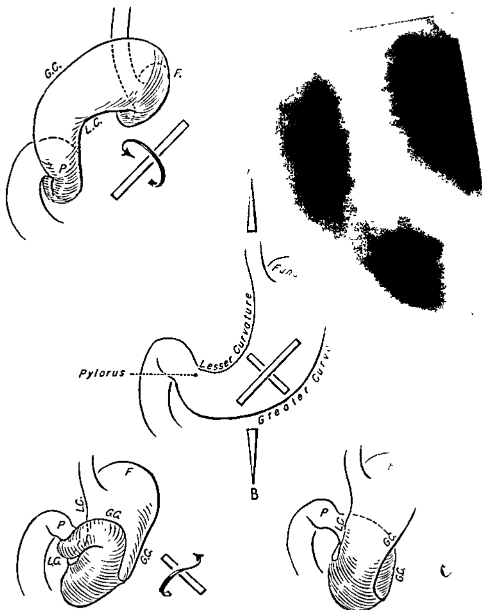


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C. CECUM

The cecum is poorly attached to the lateral abdominal wall in about 10 to 15 per cent of all adults. This factor makes torsion of this segment fairly common. Fixation of the mid-ascending colon by dense omental adhesions may lead to a fixed point that increases the possibility of volvulus. Volvulus of the cecum occurs at all ages but is commonest in young adults. It may be encountered immediately after operation for some other disease.

Minor symptoms are likely to be confused with those of appendicitis, since they consist of recurrent attacks of right lower quadrant pain, sometimes associated with vomiting. At operation the negative appendix and the large, freely mobile cecum suggest the diagnosis.

Volvulus of the cecum may be acute in its onset, or dull pain may be present for several days. The symptoms of intestinal obstruction are definite, but the exact cause is less obvious. The X ray examination is the best guide. A large bubble of gas representing the distended cecum is generally visible so high in the left upper quadrant that it may be mistaken for the stomach. If the patient has had a barium enema demonstrating nonrotation of the colon, the chances of volvulus of the cecum are enhanced. The final differentiation can be made by an immediate barium enema. These signs have been described in more detail by McGaw, Kremen, and Rigler (Fig. 89).

Several methods of operative treatment are available. The volvulus usually will be found to be clockwise, involving relatively little ileum. Simple detorsion is an invitation to recurrence and should at least be accompanied by fixation of the cecum. This may be accomplished by a tube cecostomy that simultaneously decompresses and fixes the cecum firmly by inflammatory adhesions. At the Massachusetts General Hospital we have found this procedure satisfactory in the absence of strangulation. If the colon is nonrotated, this fixation may have to be made in the mid-abdomen rather than in the right lower quadrant.

A more satisfactory operation consists of primary resection and anastomosis. In early cases this is a relatively simple procedure, since the distal colon is of normal size and the ileum only moderately dilated. Resection, of course, is necessary if there is impairment of circulation of the cecum.

D. TRANSVERSE COLON

The transverse colon, though often redundant, rarely is the source of volvulus. This fact is due to the wide separation of the hepatic and splenic flexures. Abnormal adhesions or omental fixation of two limbs in close proximity is necessary to produce volvulus.

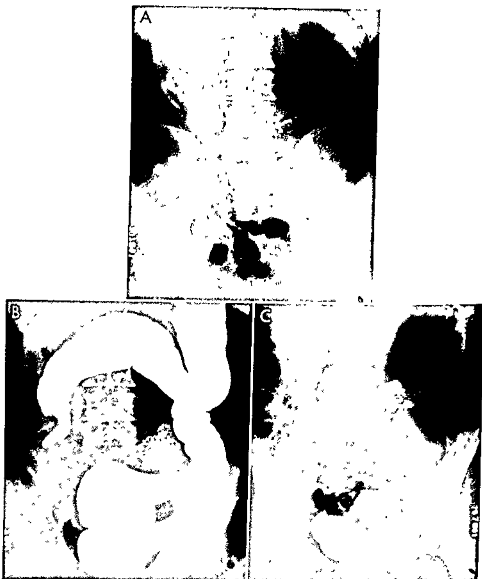


Fig. 89.—Volvulus of cecum. **A,** flat film. Note large bubble of air in distended cecum filling left abdomen. **B,** barium enema shows twist in mid-ascending colon. **C,** postevacuation film. Patient was treated by resection and primary anastomosis. Recovery was uneventful.

be obtained. In most instances there is excessive abdominal distention and the involved loop of sigmoid can be palpated through the abdominal wall. On X ray examination enormous loops of colon are visible, full of gas and fluid (Fig. 90). Final confirmation is obtained by the barium enema. The obstructing twist of the sigmoid produces a characteristic conical obstruction closely resembling a bird's beak (Fig. 91). Incomplete obstruction may show spiral folds of mucous membrane. The examiner should not insert much barium suspension for examination, since a megacolon is often present and an embarrassing retention may result.

The diagnosis of sigmoid volvulus is not particularly hard, but the choice of treatment is difficult. While it is clear that recurrence of a volvulus is extremely common after simple detorsion, advanced age or a debilitating disease often makes some procedure less radical than resection more attractive, even though it proves to be only a temporary expedient.

Consequently there has been considerable interest in nonoperative treatment. This was used by Holmgren and later by Bruusgaard, who, in 1947, reported 130 cases treated without surgery. Bruusgaard inserts a proctoscope to the point of torsion and if the mucous membrane is of good color passes a lubricated rectal tube, about 60 cm. long and about the diameter of a finger, past the obstruction. It must be inserted gently, without force. Deflation is often dramatic, sometimes to the discomfiture of the surgeon. Because of the tendency to recurrence, the tube must be sewed to the anus and allowed to remain two or three days. Among patients who could be treated in this way, Bruusgaard had four deaths. Those patients in whom decompression could not be satisfactorily performed or in whom strangulation was suspected had immediate operation.

A similarly happy result was reported from the Massachusetts General Hospital by Hamlin, who, in a series of 11 cases, was able to effect decompression without mortality, while only one patient required primary operation.

Operative treatment involves laparotomy and a choice of either detorsion, an obstructive resection, or primary resection and anastomosis. Cecostomy and colostomy are contraindicated, while obstructive resection tends to be difficult because mobilization of sufficient colon may not be easy. If detorsion is done, there must be no evidence of circulatory damage. Immediate decompression is accomplished through an inlying rectal tube. Resection and primary anastomosis are easily accomplished in many patients, particularly when the onset has been acute and little proximal dilatation of the colon has occurred. This method gradually is gaining favor in many clinics. In Massachusetts General Hospital, proctoscopic intubation is preferred when it appears to be safe. This is followed in a few days by resection of the sigmoid in good-risk patients. Old debilitated patients may be allowed two attacks of

E. SIGMOID COLON

The sigmoid is a common source of volvulus because two limbs of a redundant bowel are anchored closely together at the base of the flexure. Since recurrent mild attacks of obstruction may have led to barium studies, many patients already are known to have Hirschsprung's disease, acquired megacolon, or sigmoid redundancy. A torsion is diagnosed with the onset of com-

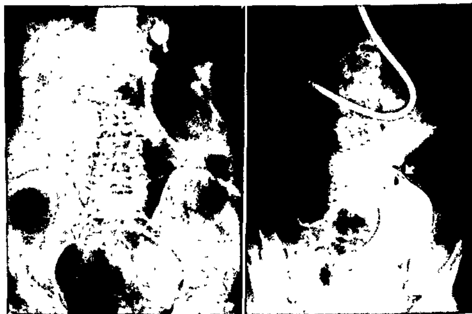


Fig. 90 (left).—Volvulus of sigmoid. Abdominal film shows enormous distention of colon.
Fig. 91 (right).—Volvulus of sigmoid shown by barium enema. Note typical spiral folds that identify site of volvulus.

plete obstruction. Volvulus of the sigmoid is much commoner in the aged; complicating diseases, therefore, are likely to sway the surgeon's choice of operative procedures. It has been found that unless sigmoidectomy is performed, recurrent attacks are the rule.

This is the typical kind of volvulus seen in eastern Europe because of the redundant colon and predominantly vegetarian diet. It also is common in Bolivia among the native laborers in mines. Lead poisoning has been observed by Berger and Lundberg to initiate the disease. The enormous size of the colon in lead poisoning is shown in Figure 111.

The diagnosis is based upon the typical manifestations of large-bowel obstruction. A history of previous, less acute attacks, relieved by enemas, may

be obtained. In most instances there is excessive abdominal distention and the involved loop of sigmoid can be palpated through the abdominal wall. On X ray examination enormous loops of colon are visible, full of gas and fluid (Fig. 90). Final confirmation is obtained by the barium enema. The obstructing twist of the sigmoid produces a characteristic conical obstruction closely resembling a bird's beak (Fig. 91). Incomplete obstruction may show spiral folds of mucous membrane. The examiner should not insert much barium suspension for examination, since a megacolon is often present and an embarrassing retention may result.

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volvulus before resection is carried out. When deflation cannot be accomplished through the sigmoidoscope, the decision between detorsion (which preferably is followed by resection at an optimal time) and primary resection and anastomosis must be made on the individual circumstances.

19

Bands and Adhesions

BANDS AND ADHESIONS constitute the most frequent cause of obstruction of the small intestine. Because of its larger lumen, straighter course, and greater degree of fixation, the colon is implicated much less frequently in this type of obstruction. Adhesive obstruction now accounts for 39.2 per cent of the intestinal obstructions seen in the Massachusetts General Hospital. This figure compares with 30 per cent found by McIver in this hospital in 1930. Thirty-one per cent of all cases of obstruction were caused by adhesions, either early or late, in the University of Minnesota series from 1942 to 1953.

ETIOLOGY.—The bands or adhesions may be congenital. For example, Meckel's diverticula often are associated with bands that extend to the umbilicus. Dense bands associated with malrotation may obstruct the duodenum. After certain intraperitoneal inflammatory processes, such as tuberculosis, adhesions are frequent. A strand of omentum adherent to a calcified mesenteric lymph node or to diverticulitis of the sigmoid indicates somewhat similar processes that initiate adhesive obstruction. Intraperitoneal abscesses commonly cause obstruction. Trauma may initiate adhesions. However, the great majority of bands and adhesions follow operative procedures. In the Massachusetts General Hospital 1947-1955 series, postoperative adhesions accounted for 82 per cent of all adhesive obstructions; Perry, Smith, and Yonehiro found this figure to be 79 per cent, and Becker, 90 per cent.

Pelvic operations are much more likely to be followed by obstruction than are upper abdominal operations, because the intestinal coils gravitate readily into the pelvis. *Particular care must be taken by the surgeon at every* operation if he wishes to avoid obstruction. Infection at the operative site, rough handling of tissues, wiping the intestine with gauze, large ligatures that cause necrosis of masses of fatty tissue, failure to peritonealize carefully, and

insertion of foreign bodies, including wicks, gauze, and talcum or other dusting powders, are all important details. It has become the fashion to minimize the protective action of the peritoneum, since, in some radical cancer operations, large sections of it must be sacrificed and relatively little obstruction has been reported thereafter. The author has found this a dangerous philosophy. The surgeon should be most insistent on careful peritonealization whenever it is possible. Thus, the appendiceal stump should be inverted after appendectomy and the pelvic floor carefully covered with peritoneum after hysterectomy.

Talcum powder granulomas have produced a troublesome type of obstruction. The adhesions are dense, sometimes are associated with intestinal fistulas, and tend to recur after operation. This granuloma first was described by Anapal in 1933. Starch dusting powders are much safer. They, however, are not entirely innocuous, since the starch tends to form irritative masses if clumps of powder are placed in the peritoneal cavity.

The role of the omentum in the production of postoperative adhesions is a most important one. It formerly was the custom to ascribe a protective influence to the omentum as a localizer of infection and as an intervening structure which would prevent adhesions of intestinal loops to a fresh peritoneal incision. It is now much more popular to consider the omentum a culprit rather than a policeman. Partial or total omentectomy is advisable in many operations for obstruction.

PATHOLOGY.—Postoperative adhesions begin as soft, vascular depositions of fibrin at a site of infection or trauma. They gradually become thickened and vascularized. Many will be absorbed; others progress to the formation of short dense bands or persist as filmy adhesions. Partial or complete obstruction may occur at any time if a sharp kink produced in the bowel finally becomes occluded by a bolus passing down the intestinal canal. At times an adhesion forms a fixed point, and distal to it a complete volvulus may occur.

Postoperative adhesions may produce obstruction at any time after operation. They are divided arbitrarily into early postoperative obstruction, occurring within two weeks of the primary operation, and late obstruction. Obstructions tend to be much commoner soon after operation and become progressively less frequent as time goes on (Table 8).

The incidence of strangulation in this type of obstruction is an important figure to determine. If strangulation is comparatively rare there can be little objection to treating many patients conservatively by suction; if the incidence is high, or if strangulation cannot be recognized accurately, early operative treatment becomes essential.

At the Massachusetts General Hospital, strangulation has been noted in 11.5 per cent of cases. Perry *et al.* found it in 11.8 per cent of all adhesive ob-

structions, while Becker found it in 21.3 per cent. The incidence of strangulation, therefore, is high enough to cause concern.

It is even more important to know whether or not the strangulating obstruction can be recognized. There is no question but that increasing familiarity with the disease makes the recognition of strangulation more certain.

TABLE 8.—INTERVAL BETWEEN LAST OPERATION AND OCCURRENCE OF OBSTRUCTION DUE TO ADHESIONS

	TOTAL NO. OF CASES	PERCENTAGE OF TOTAL	PERCENTAGE OF TOTAL APPEARING EACH WEEK
Less than 2 weeks	72	22.4	11.2
2-4 weeks	28	8.6	4.3
1-3 months	22	6.8	0.8
3-6	28	8.6	0.7
6-12	34	10.4	0.3
1-2 years	24	7.3	0.1
2-3	9	2.7	0.05
3-4	8	2.4	0.04
4-5	6	1.8	0.03
5-10	44	13.4	0.05
10-15	14	4.3	0.01
15-20	10	3.0	0.01
20-25	6	1.8	0.01
25-30	11	3.4	0.01
30-40	8	2.4	0.01
40-50	2	0 6	
50-60	1	0.3	

Perry *et al.* believe that the danger of lack of recognition of strangulation is slight. Becker believes it is high. McKittrick and Sarris have shown, in the Massachusetts General Hospital, that within the first 24 hours attempted differentiation of simple and strangulating obstruction due to adhesions is attended by a high error.

METHODS OF PREVENTING ADHESIONS.—Prophylaxis of peritoneal adhesions has never been completely successful. The methods were divided by Boys in his comprehensive discussion into five groups as follows.

1). The limitation or peritoneal injury by scrupulous aseptic technique, gentle handling of tissues, careful hemostasis, avoidance of intraperitoneal use of chemical solutions, avoidance of thermal injury by hot solutions or the cautery, and avoidance of leaving behind unnecessary foreign bodies in the peritoneal cavity.

2). Direct inhibition of fibroblastic tissue proliferation. Of various substances tried, cortisone, administered pre- and postoperatively, will diminish the incidence of adhesions, according to Hubay, Weckesser, and Holden,

but very large doses are required. Hyaluronidase, in the rat, exerted no discernible influence in the experiments of Craig and Bianchi.

3). Separation of injured peritoneal surfaces until mesothelialization has occurred. Membranes, lubricants, pneumoperitoneum, and stimulants to maintain bowel activity have been used. Various fluids have been placed in the peritoneal cavity to separate the intestinal loops. Experimentally, Schiff, Goldberg, and Necheles found in dogs that early feeding and stimulation of peristalsis by neostigmine (Prostigmin) led to a 71 per cent decrease in obstructing adhesions.

4). *Methods to permit removal of fibrin already deposited upon peritoneal surfaces.* Fibrolysins, including papain, have not been successful. Substances that stimulate intraperitoneal leukocytosis, such as amniotic fluid, have not been shown clearly to be of any value. Amniotic fluid, however, is at least harmless.

5). *Use of substances that prevent coagulation of the peritoneal exudate.* Heparin gave promising results, but later experience has shown that it carries too great a hazard of hemorrhage to be safe.

TREATMENT.—Treatment of early postoperative obstruction due to bands and adhesions will be discussed in Chapter 25. In late adhesive obstruction, the site of occlusion is nearly always in the small intestine and less commonly in the colon. According to the statistics noted above, in approximately 10 to 15 per cent of the cases, strangulation is present.

There is no argument about the proper treatment of obstruction that is actually or probably strangulating. On the other hand, there is no general agreement as to the proper therapy of obstruction that is presumably due to bands and is nonstrangulating. The points of view were discussed in Chapter 6 but will be recapitulated here.

Perry, Smith, and Yonehiro presumably reflect Wangensteen's teaching and believe that simple obstruction due to bands and adhesions should be treated primarily by intestinal intubation. Patients with early and late postoperative obstruction due to adhesions are treated similarly. Of 388 patients, 120, or 31 per cent, were treated by intubation with relief of obstruction and were discharged without operation. Suction treatment was interrupted if distention of the bowel was not relieved within 12 hours or if signs of strangulation developed. Such interruption was necessary in 188 of the 388 patients. Immediate surgery after intubation was carried out in the remaining 80. Of all the patients, 193 had gastric suction and 195 had a long intestinal tube. The over-all mortality was 9.5 per cent.

In the Massachusetts General Hospital a different program has been followed. Treatment by intubation has been used as the sole method of therapy in only 30 of 334 cases (9 per cent); many of the patients were suffering from

obstruction that occurred just too late after a previous operative procedure to be classified as early postoperative obstruction but occurred within four weeks of this operation, so that there was some hope that relief from the simpler method might be permanent.

In the Massachusetts General Hospital figures, there were 17 deaths from all causes in this group of 334 cases of adhesive obstruction appearing more than two weeks after a previous operation, an over-all mortality of 5.1 per cent. *Of the 17 patients who died, four were moribund on entry; the mortality rate* for treated patients was therefore 3.9 per cent. This mortality figure is low enough, we believe, to suggest that the optimal method of therapy of late postoperative adhesive obstruction is operation. The problems are to select the proper time for operation and to choose the correct procedure.

The timing of the operation was discussed in Chapter 6. Briefly, all patients seen within 24 hours of onset of symptoms are operated on immediately. Those seen after 24 to 48 hours usually are operated on at once, but in the absence of signs of strangulation, a few hours may be taken for preparation; this includes the insertion of a long tube. After 48 hours of obstruction, in the absence of strangulation, immediate operation is unusual. Several hours, or even a day or more should be allowed for intensive preoperative therapy, including intubation.

The operative procedure usually requires a choice between lysis of adhesions and resection. In rare instances, a side-tracking anastomosis may be made around the adhesions or an artificial anus established above them. In the *1947-1955 Massachusetts General Hospital series, a lysis of adhesions* was performed in 243 instances, with five deaths (mortality 2 per cent); resection in 52 cases, with seven deaths (mortality 13.5 per cent), and other operations in four cases, with one death. Resection is indicated not only for strangulated but for inextricably matted intestine. The higher mortality of resection is ascribable chiefly to the more serious lesions for which it is required. The inherent risk in resection appears to be slightly higher than that in lysis of adhesions; in this series two patients died of dehiscence of a small-intestinal anastomosis, while only one died of perforation secondary to lysis of adhesions in an intestine that should have been resected.

The operation should follow a definite plan. The abdomen is opened through an adequate paramedian incision. Preferably, old scars are avoided, since omentum and intestine are often firmly matted beneath them. However, a fresh incision should not parallel and be closely adjacent to a previous one. Serous fluid usually escapes as the peritoneum is opened. If it is bloody, strangulation nearly always, though not necessarily, is present. If many adhesions are found, dissection is first carried out between the peritoneum and

the mass of matted bowel and omentum. Eventually the actual site of obstruction is observed at the junction of collapsed and distended bowel. After release, it is well to investigate the entire small bowel to relieve any secondary points of obstruction that might be found. The distended intestine is emptied by aspiration, either preliminary to the lysis of adhesions or before the abdomen is closed. Whenever strangulation is present and the intestine does not return rapidly to normal on release of the obstructing mechanism, resection is required. Care must be taken to obtain normal intestine for the anastomosis. Inspection of the vessels for visible pulsations in the mesentery immediately adjacent to the intestine is the best guide.

20

Hernia

HERNIAS ARE DIVIDED into two major groups. In the extra-abdominal (or external) type, either a peritoneal bulge or a defect in the peritoneum itself allows protrusion of a portion of the contents of the peritoneal cavity outside the true abdominal cavity (Fig. 92). An intra-abdominal hernia, which less accurately is termed an internal hernia, is a protrusion of an abdominal viscus into one of the abdominal fossae or of the intestine through a congenital intraperitoneal defect. The numerous varieties are listed in Table 9.

TABLE 9.—CLASSIFICATION OF HERNIAS

I. Extra-abdominal (external)
  A. Inguinal
    1. Indirect (incomplete or complete)
    2. Direct
    3. Combined direct and indirect
    4. Sliding
  B. Femoral
  C. Umbilical
  D. Epigastric
  E. Ventral
    1. Spontaneous
    2. Acquired
  F. Diaphragmatic
    1. Acquired
      a. Esophageal hiatus hernia
        (1) Hiatus hernia
        (2) Parahiatal hernia
        (3) Short esophagus
      b. Caval or aortic hiatus hernias
    2. Hernia due to congenital diaphragmatic defects
      a. Partial or complete absence of diaphragm
      b. Hernia through pleuroperitoneal hiatus
      c. Hernia through foramen of Morgagni
    3. Traumatic, due to laceration of diaphragm

4. Eventration of diaphragm
G. Interstitial (properitoneal, intramuscular inguinosuperficial, or external supravesical)
H. Prevesical (or internal supravesical)
I. Lumbar
J. Obturator
K. Sciatic
L. Perineal
M. Richter's (partial enterocele)
N. Littre's
O. Appendiceal

II. Intra-abdominal (internal)
A. Into anomalous fossa
1. Paraduodenal
2. Pericecal
3. Intersigmoid
4. Through foramen of Winslow
B. Through anomalous opening
1. Through mesentery
2. Through omentum
3. Through or into broad ligament
C. Postoperative
1. About gastroenterostomy stoma
2. Behind enterocolic anastomosis
3. About ileostomy or colostomy stoma
4. Through operative defect
a. Through mesenteric trap
b. Through defect in omentum
c. Through trap left from uterine suspension
d. Through defect in pelvic floor

The relative frequency of each of these types is impossible to determine, since the incidence is variable in any hospital and depends on the age and sex of the patients admitted. Watson stated that of all external hernias 92 per cent are inguinal, 2.5 per cent umbilical, 2 per cent femoral, 1.5 per cent ventral, 1 per cent epigastric, and 1 per cent other varieties. Hiatus hernias, extremely common, are not included in these figures. About one-third of inguinal hernias and three-quarters of all femoral and umbilical hernias are in women.

Any of these hernias except small hiatus hernias may result in intestinal obstruction, though some types are much more likely to cause this complication than others. Insofar as the entire group of external hernias is concerned, the incidence of obstruction is roughly about 5 per cent. Morris and Johnson found that 3.8 per cent of all patients with hernias admitted to Bellevue Hospital between 1924 and 1937 had obstructions. The corresponding figure in the University of Minnesota Hospital from 1942 to 1953 was 8.8 per cent.

External hernias also are classified by terms other than those referring to their anatomic locations. They are, for example, either reducible or irreduc-

ible, according to whether or not their contents can be returned to the abdominal cavity. The irreducible hernias are either incarcerated or strangulated, and this differentiation must be made on the appearance of the intestine as it is exposed at the time of operation. Any interference with the blood supply, ranging from mild cyanosis of the bowel to frank gangrene, indicates the presence of strangulation. It usually is assumed that patients with intestinal obstruction from hernia have strangulation.

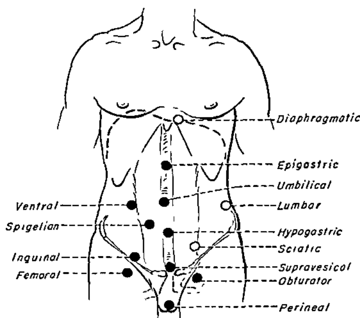


Fig. 92.—Sites of extra-abdominal hernias. Solid circles indicate hernias appearing on anterior part of body wall.

The relative incidence of strangulated external hernia as a cause of intestinal obstruction has diminished significantly in recent years. Thus, in McIver's report, this cause accounted for 44 per cent of all the acute intestinal obstructions observed in the Massachusetts General Hospital from 1920 to 1930. The corresponding figure now is 5.4 per cent.

Strangulation is relatively far more frequent in femoral than in any other type of external hernia, while umbilical hernia is the next most dangerous type. According to a survey made by Beller and Colp, femoral hernias show strangulation in 32 per cent of cases, umbilical in 15 per cent, inguinal in 4 per cent, and incisional in 3 per cent.

Strangulation nearly always involves the distal ileum. In approximately 90 per cent of cases the small intestine alone is present in an external hernia,

in 5 per cent both colon and small intestine are present, and in 5 per cent the colon alone is present.

A. EXTRA-ABDOMINAL HERNIA

1. Inguinal Hernia

The presence of an inguinal hernia as a cause of intestinal obstruction is usually easy to determine on physical examination. The characteristic bulge in the groin may be difficult to detect, however, in very obese patients or in those who have only a small knuckle of bowel strangulated at the internal ring. X ray examination may show a loop of bowel outside of the abdominal wall. In these hernias, incarceration progresses rapidly to strangulation; operation, therefore, is necessary as soon as possible after the hernia has been found to be irreducible. Small intestine may become gangrenous within six hours after the onset of symptoms of incarceration. Local tenderness over the sac is the commonest early sign of strangulation; later, all the signs of strangulation obstruction appear.

Unless immediate hospitalization is impossible, no attempt should be made to reduce the hernia. It now is far safer to plan an emergency operation than to carry out manipulations designed to secure reduction.

Forcible reduction of hernias has led to many catastrophes. A section of devitalized intestine may be pushed back into the peritoneal cavity and perforate later. A section of matted intestine that is obstructed by adhesions rather than by the hernial ring may be returned to the peritoneal cavity with no relief of the underlying obstruction. The herniated intestine may be reduced together with the constricting internal ring; this type of "en bloc" reduction is certain to be fatal unless it is recognized and corrected very rapidly by laparotomy. Consequently, though reduction by manipulation or taxis is still described, the maneuver is now rarely necessary.

The anesthesia chosen for operation must depend on the age and the condition of the patient. While a general anesthesia usually is selected and always is necessary for the very young, great care should be taken to select a proper agent for the elderly, those with severe respiratory difficulties, and those who have a full stomach, either from recent food ingestion or from the concomitant intestinal obstruction. In many of these patients local anesthesia is the method of choice.

Inguinal hernias in infants or children should be repaired as soon as they are discovered. Smith, in a study of 546 hernias in children in the General Infirmary in Leeds, from 1948 to 1951, found that 50 were irreducible; 28 per cent of all irreducible hernias showed strangulation at operation and with 4 per cent there was gangrenous intestine; 96 per cent occurred in males

and 74 per cent were on the right side. The incidence of irreducibility was much higher under the age of 12 months than at any other period in life.

METHOD OF LOCAL ANESTHESIA.—Ten cubic centimeters of 1 per cent procaine hydrochloride (Novocaine) is injected into the oblique muscles just above the internal ring; 10 cc. is inserted through a second puncture near the pubic spine, infiltrating the rectus sheath. A third similar injection is then made near the femoral vessels, at the level of Poupart's ligament. This field block is supplemented by infiltration along the line of incision, and later, after accurate exposure, of the peritoneum at the internal ring (Fig. 93).

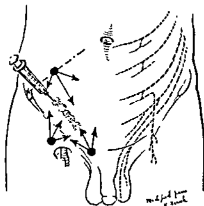


Fig. 93.—Local anesthesia for hernia. Solid circles indicate sites for field block. Each arrow represents 3 to 5 cc. of 1% Novocaine. Line of incision also is infiltrated.

SURGICAL THERAPY.—The purposes of the operation are to identify and release the point of obstruction, to return normal intestine to the peritoneal cavity, and to repair the hernia; usually all can be fulfilled, though in some instances, when the patient is very ill, accomplishment of only the first is possible.

The point of obstruction nearly always is the internal ring, which is often extremely tight. Rarely, the external ring may be the site of the obstruction, and occasionally there are bands or adhesions of intestine or omentum within the sac itself. The constricting mechanism must be cut before the viability of the intestine can be ascertained. When the internal ring is at fault, it should be cut by an incision lateral to the ring, rather than medially or superiorly. This incision will avoid the deep epigastric vessels and avert troublesome hemorrhage.

Determination of the viability of the intestine usually is not difficult. Not only should there be careful observation of the loops in the sac, but intestine should be withdrawn from the peritoneal cavity and inspected both proxi-

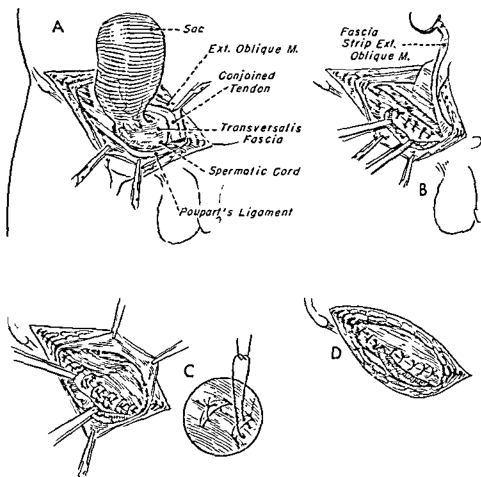


Fig. 94.—Modified McArthur repair of strangulated inguinal hernia. **A,** sac has been identified and mobilized. **B,** sac has been opened, intestine returned to peritoneal cavity or resected, sac excised, and neck closed. *Transversalis* fascia is closed on posterior wall of canal. Strip of fascia is cut from the upper leaf of external oblique, leaving it attached at lower end. **C,** conjoined tendon is sutured to Poupart's ligament with fascial strip and with series of cotton sutures that catch each loop of fascia, Poupart's ligament, and conjoined tendon. Lowest suture is placed in periosteum of pubis. **D,** external oblique has been closed beneath cord. Superficial fascia and skin will be closed in separate layers.

mally and distally to be sure that no gangrenous intestine has escaped back into the peritoneal cavity. The presence of normal peristalsis running through the area and a normal sheen on the surface of the bowel are helpful signs. The application of warm saline solution is valuable for the few minutes the intestine is under observation. If the color of the bowel does not improve significantly or if pulsations do not reappear in the adjacent mesentery within 15 minutes, resection should be carried out.

Whenever viability is doubtful, it is wisest to resect the intestine. If doubtful, bowel is returned to the peritoneal cavity, there is danger of early perforation, hemorrhage from a mucosal ulcer, or late stricture in the devascularized area. Clinical experience has shown that the addition of a resection does not increase operative mortality but that retention of damaged bowel is very serious.

Resection should be followed by an accurate end-to-end anastomosis. Formerly a double-barreled ileostomy was done rather commonly when the operation had to be terminated rapidly. Now, fortunately, such a maneuver is rarely considered to be necessary. Likewise, the procedure of exteriorization of a loop of doubtful viability has been outmoded.

Repair of the hernia is carried out in as careful a fashion as allowed by the condition of the patient. In early cases it need not vary from the standard repair. In infants and children, the Ferguson repair is all that is necessary. While the writer prefers a McArthur repair in adults (Fig. 94), this should be replaced by a simpler Halsted or Bassini operation if a gangrenous intestine has increased the chances of infection or there is marked edema of the muscle layers. In desperate cases, only herniotomy may be possible and the herniorrhaphy neglected.

2. Femoral Hernia

Femoral hernias differ in several important ways from the inguinal variety. They are often more difficult to diagnose, since the sac may be buried deeply in fat. Richter's hernias are commoner in femoral than in inguinal hernias. Also, the relative incidence of strangulation is eight to 10 times higher with femoral than with inguinal hernias.

The mortality rate rises rapidly with the lapse of time after strangulation has occurred, since nonviable intestine may be encountered a few hours after the onset of symptoms. McNealy and Lichtenstein found that the mortality was 6.6 per cent if operation was performed within 12 hours, was 16.2 per cent if it was performed within 24 hours, and rose gradually to 36 per cent if strangulation had been present for a week or more.

On the other hand, in some respects femoral hernia furnishes a particularly favorable type of strangulating obstruction, because the bowel is caught so

tightly in the sac that the gangrene and resultant infection are localized in an extra-abdominal position. This localization makes it possible to disassociate the effects of intestinal obstruction and of gangrenous bowel, a feature

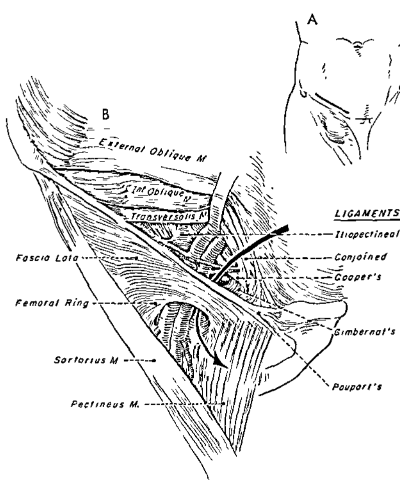


Fig. 95.—Early strangulated femoral hernia. **A**, inguinal incision is made parallel to and just above inguinal ligament. ***B***, *anatomy of femoral canal* (***continued***).

not encountered in types of strangulating obstruction other than external hernia.

The surgeon must select his operation on the basis of the amount of infection that he expects to discover in the sac. Femoral hernia without obstruction should be operated on with little or no mortality. This likewise is true of femoral hernia complicated by intestinal obstruction when the bowel is viable. When both intestinal obstruction and gangrene are present, a high mortality results. In Dunphy's series of 201 patients operated on in the

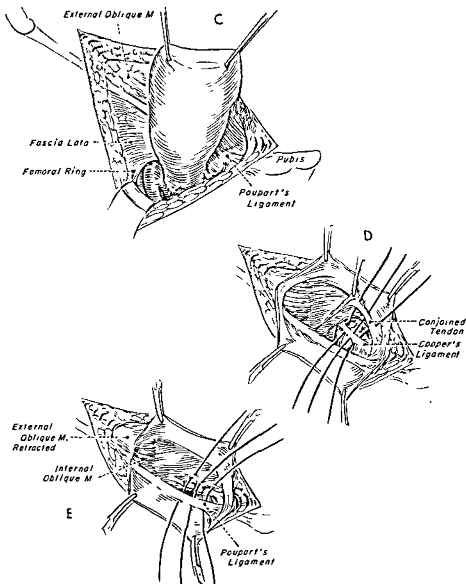


Fig. 95 (cont.).—**C**, sac is exposed by dissection beneath Poupart's ligament, mobilized, and opened. *Intestine is then returned to peritoneal cavity or resected as indicated.* **D**, external oblique has been opened just above Poupart's ligament. Sac has been excised and neck closed. Cotton sutures now unite conjoined tendon to Cooper's ligament by McVay's technique, effectively closing femoral canal. **E**, second layer of sutures through conjoined tendon draws it down to Poupart's ligament. External oblique, superficial fascia, and skin are closed in separate layers.

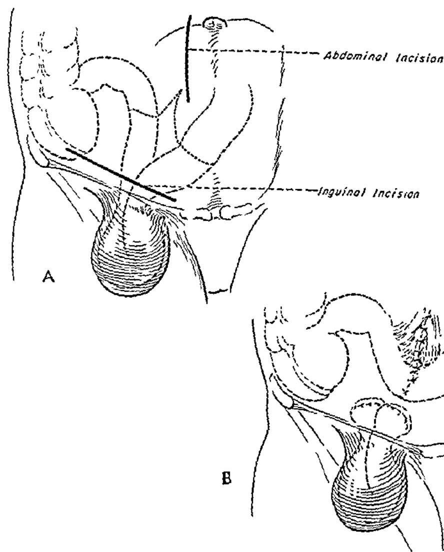


Fig. 96.—Combined abdominoinguinal approach for late strangulated femoral hernia. Similar combined approach is often advisable with other rare extra-abdominal hernias, such as obturator, sciatic, and perineal; for these, external incision is made at site of hernia. **A**, abdominal incision is made; intestine is resected, and divided just within hernial ring, as shown by broken line. **B**, intestinal continuity has been restored and ends of herniated loop closed (**continued**).

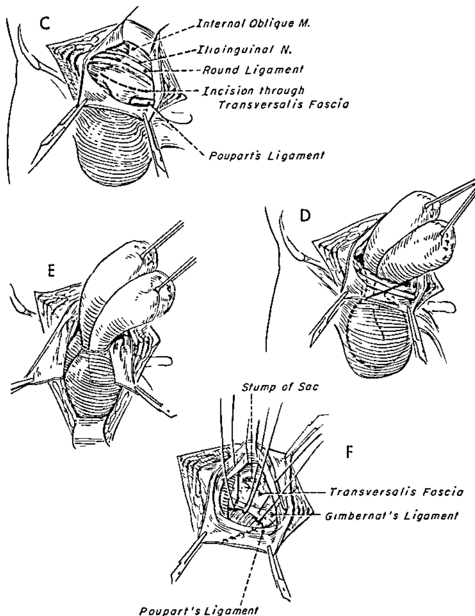


Fig. 96 (cont.).—C, inguinal incision is made. Dissection is entirely in clean field above Poupart's ligament. Neck of sac is identified and peritoneum opened just above it by incision through transversalis fascia. **D,** through this incision, loops of intestine are delivered. Neck of sac is divided completely. Peritoneum in inguinal incision and abdominal incision now are closed. Any contamination that takes place in remainder of operation will be excluded from peritoneum. **E,** sac is mobilized below Poupart's ligament and completely excised, together with loop of intestine. If necessary, Poupart's ligament may be partially or entirely divided. **F,** repair is completed, conjoined tendon being sutured to Cooper's ligament.

Peter Bent Brigham Hospital, the mortality for patients with gangrene was 50 per cent, while the others were operated on with no deaths.

The approach may be either inguinal, femoral, or combined. An excellent exposure may be obtained if an oblique incision is made just above Poupart's ligament and the dissection carried out both above and below the ligament. The sac is mobilized from below and opened. Meanwhile the neck of the sac is exposed from above. Omental adhesions, if present, are freed and viable intestine returned to the abdominal cavity. Since the neck of the sac often is very tight, gentle dilatation of the aperture may not be sufficient. Forcible dilatation with a clamp is contraindicated because of the danger of tearing the femoral vein. If necessary, Poupart's ligament is divided either partially or completely.

After reduction and excision of the sac, the neck is closed. Repair of the hernia is done most effectively by the Cooper's ligament method of McVay, and this method is essential in cases in which Poupart's ligament has been cut (Fig. 95). In other cases, Poupart's ligament is attached to Cooper's by interrupted cotton sutures or by a strip of fascia taken from the external oblique, as described by Payne.

In later cases, six to 24 hours after the onset of symptoms, strangulation usually is present. The sac is exposed in the same fashion. If it is bluish-black and full of fluid, the bowel is strangulated and almost surely gangrenous. The sac is opened. It then almost surely will be necessary to cut a portion or all of Poupart's ligament, since edema will be a prominent feature. Thereafter the usual tests of viability of the bowel are carried out, and intestinal resection is done if necessary.

When the symptoms of obstruction have been present for over 24 hours, strangulation is almost certain to be present. In this case the surgeon should recognize the fact, mentioned above, that the treatment of intestinal obstruction and of sepsis due to the strangulated bowel can be divorced and treatment thereby made much safer.

Dennis and Varco's method involves exposure of the hernia through the usual incision. The sac, together with the strangulated bowel, then is excised *in toto* after isolating normal intestine running into the sac. This method is illustrated in Figure 97.

The writer has used an abdominal approach (Fig. 96). The abdomen first is opened through a lower-rectus incision. The loop of intestine that enters the hernial sac is identified readily. The upper small bowel, if still distended, is emptied of its contents, preferably by drawing down the tip of a previously placed long intestinal tube. If this tube is not in proper position, the intestine is emptied by aspiraton.

The afferent and efferent loops of intestine then are divided close to the

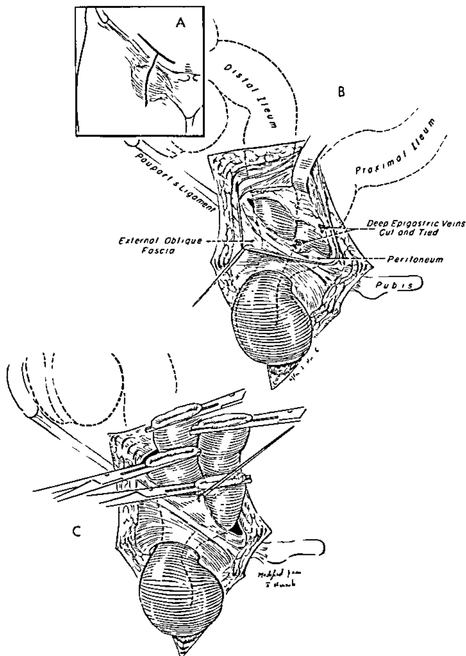


Fig. 97.—Dennis' method for femoral hernia. **A**, a T-shaped incision is made. **B**, peritoneum opened through floor of inguinal canal. **C**, loops of intestine have been identified and divided. The upper pair will be anastomosed and peritoneum closed. Lower pair will be excised with hernial sac.

entrance to the sac, together with the mesentery of the incarcerated bowel. An end-to-end anastomosis of the normal bowel is carried out and the ends of the isolated loop turned in. This disposes of the problem of the intestinal obstruction. The abdominal incision then is closed and a new incision made directly over Poupart's ligament. The peritoneal cavity is entered, and the blind ends of intestine withdrawn. The peritoneum then is closed. Thereafter, the sac is opened, and the loop of gangrenous bowel removed. Preferably the sac is then excised and the hernia repaired. However, if there has been extensive contamination it is more logical to leave the sac, institute drainage, and plan to repair the hernia at a later date.

3. Umbilical Hernia

The umbilical hernia frequently contains incarcerated omentum. In addition, as pointed out above, strangulation of a loop of transverse colon or intestine is commoner than in any other type of hernia except the femoral. Extreme obesity often is a complicating factor, and secondary infection of the sac and its contents may result from intestinal perforation within it. The mortality for such obstruction, therefore, is high.

The repair of uncomplicated umbilical hernia is readily accomplished by the Mayo type of repair, in which a transverse incision is made, the sac excised, the peritoneum closed, and the rectus fascia overlapped to close the defect. When the hernia is irreducible, a vertical incision is best, since it can be extended and the entire peritoneal cavity explored when necessary.

4. Epigastric Hernia

Epigastric hernias may occur anywhere along the linea alba. Primary epigastric hernias are common, but the hypogastric are rare. While these hernias frequently are incarcerated, they usually contain only a pad of properitoneal fat. Strangulation of the intestine is rare. When gut is present, the transverse colon is usually involved, though small intestine occasionally is found.

5. Ventral Hernia

Ventral hernias are divided into two groups, spontaneous and acquired. The acquired follow operative incisions or trauma. The spontaneous hernias include several rare types—hernia in the linea semilunaris (Spigelian hernia), hernia in the linea transversae, and hernia in the sheaths of the rectus muscle. Koontz reported seven cases of Spigelian hernia and summarized the available literature.

Postoperative ventral hernias are by far the commonest and frequently

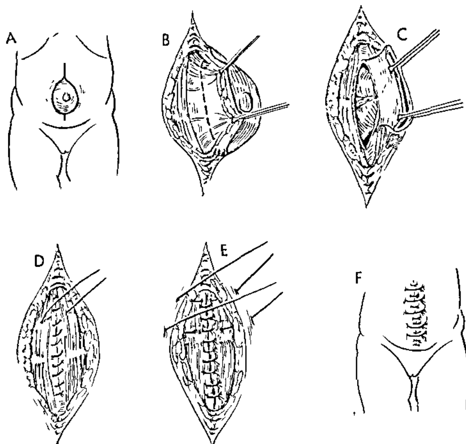


Fig. 98.—Umbilical and ventral herniorrhaphy for intestinal obstruction. A, vertical excision is preferred, thin skin at umbilicus being excised B, rectus is retracted and peritoneum opened. C, excision of sac and underlying skin is to be followed by relief of obstruction by lysis of adhesions or resection. D, peritoneum and posterior rectus sheath have been closed. Rectus muscles are sutured together. E, closure of anterior fascia. Retention sutures are advisable. F, final closure.

produce acute obstruction. For this reason they should be repaired prophylactically.

When operation is required for acute obstruction, the surgeon hopes to achieve several objectives, including relief of the obstruction, adequate exploration of the peritoneal cavity to make certain that no other obstructing mechanisms are present, and repair of the hernia. A wide incision is made, the previous operative scar being removed. Great care is necessary to avoid injury to the underlying intestine. It is best to enter the peritoneal cavity slightly above the previous peritoneal incision to facilitate dissection. Adher-

ent omentum and intestine are freed and all ramifications of the hernial sac opened. Since obstructing intraperitoneal adhesions commonly are found associated with such a hernia, a rapid examination of the entire small intestine should be made. The colon must be palpated and the pelvis and upper abdomen examined to make certain that there is no other cause of obstruction. Aspiration of the intestine or resection of gangrenous or badly scarred intestine may be necessary. Finally the hernia is repaired by freshening the peritoneal edges, dissecting out muscle layers, and closing the incision in layers. Multiple tension sutures are placed. The use of fascia is contraindicated in operations on these ill patients (Fig. 98).

Occasionally the patient may be so ill, or the hernia so huge, that any attempt at repair or even complete dissection is contraindicated. The surgeon may feel that he can do no more than cut the constricting ring of the hernial sac or decompress a distended loop in the sac by enterostomy. Neither of these procedures is very satisfactory, since they frequently fail to eliminate the obstruction and form a high intestinal fistula that may prove fatal.

6. Diaphragmatic Hernia

Diaphragmatic hernias usually are classified according to their cause and by the anatomic site in which they appear. Of the acquired hernias, esophageal hiatus hernias are by far the most important, while caval or aortic hiatus hernias are rare. The congenital hernias occur in specific areas, while traumatic hernias appear anywhere in the diaphragm. Eventration of the diaphragm, though often classified as such, is not a true hernia (Fig. 99).

Incidence.—Hiatus hernias can be demonstrated radiologically in at least 20 per cent of patients over 50 years of age who are examined. They are, therefore, much commoner than all other types of hernia combined. However, hiatus hernias are relatively unimportant causes of intestinal obstruction, while the congenital and traumatic hernias are very likely to produce it.

Symptoms.—The diagnosis of a diaphragmatic hernia, with the exception of hiatus hernia, may be difficult in the absence of intestinal obstruction. Vague digestive symptoms, substernal burning, or fullness after eating may lead to X ray examinations and demonstration of the hernia. The chest plate may reveal unusual density behind or near the cardiac shadow if an intrathoracic loop of intestine is full of fluid or a typical colonic pattern if the colon is present and full of gas. Pulmonary symptoms predominate in infants. Pain may be typical of a hiatus hernia or may mimic that of cardiac disease. On the other hand, symptoms of intestinal obstruction may give the first clue to the diagnosis. Intestinal obstruction occurring after a fractured rib or after

other injury which might have lacerated the diaphragm, such as a stab or gunshot wound, should always raise the question of a traumatic hernia of the diaphragm.

Strangulated diaphragmatic hernia in adults usually follows a sudden strain or trauma that forces the stomach or intestine into the thoracic cavity. Pain is sudden, severe, and steady, localized in the epigastrium. Shock, dyspnea, nausea, vomiting, and obstipation follow.

Carter and Guiseffi emphasized a striking consistency in the history and physical findings in four cases of traumatic diaphragmatic hernia that they

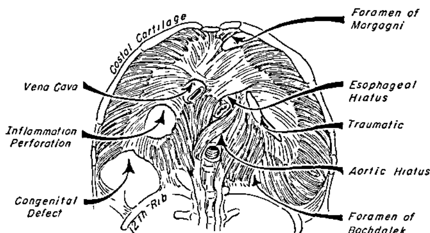


Fig. 99.—Diaphragmatic hernias. Sites of diaphragmatic hernias are fixed anatomically except for traumatic hernias and inflammatory perforations, which may appear in any location.

observed and 39 that they collected from the literature. There is a history of a previous thoracic injury. The interval may be as short as one day, and in 85 per cent of the cases hernia occurred within three years of injury. The physical findings usually are referable to the left chest and include displacement of the heart to the right, dullness or tympany in the lower portion of the thorax, adventitious sounds, and aspiration of bloody fluid from the left pleural cavity. The roentgenologic findings suggest a high left diaphragm with displacement of the heart to the right. Finally there are signs of acute gastrointestinal obstruction, but when the stomach alone is involved there is no abdominal distention. Colon, stomach, and small intestine are involved in the hernia in that order of frequency.

The treatment of diaphragmatic hernia uncomplicated by intestinal obstruction will not be considered. For this hernia with obstruction, an abdominal approach is best, since only by this means can the surgeon be sure that he

has not overlooked any other point of obstruction. At times it is necessary to enlarge the exposure by a thoracoabdominal incision. After withdrawal of the abdominal viscera, the diaphragm is closed by nonabsorbable sutures.

Diaphragmatic hernias in newborn infants constitute grave surgical emergencies. The defects are usually large, comprising the posterior quarter of the diaphragm. In rare instances, nearly an entire leaf of the diaphragm is absent. Severe cyanosis is produced by compression of the lung. This is followed shortly by signs of intestinal obstruction, which may be at the level of stomach, small intestine, or colon. Operation should be carried out within the first day or two of life, since if it is not done, in about 90 per cent of cases the infant will be dead in three months, according to Koop. He prefers a transthoracic approach, while Gross uses the abdominal so that other causes of intestinal obstruction can be excluded. Gross has encountered an associated malrotation of the colon in about one out of six cases and has reported 72 cases with eight deaths. They occurred as follows: left posterolateral, 53; right posterolateral, 10; esophageal hiatus, five, and foramen of Morgagni, four.

When repair is carried out through the abdomen, the abdominal viscera must be withdrawn gently from the chest, stomach first, then intestines, then liver or spleen. The viscera are placed outside of the abdominal cavity, the hernial sac exposed, the lung inflated, and the defect closed with interrupted silk sutures. Closure of the defect will be extremely difficult if the opening is large or if there is congenital absence of an entire hemidiaphragm; the liver or tantalum mesh have been used in such circumstances. Closure of the abdominal wall becomes increasingly difficult as time goes on because of intestinal distention.

Eventration of the diaphragm implies that the diaphragm is intact but atrophic. The degree of elevation varies considerably. A very high diaphragm due to congenital eventration will produce severe cyanosis and dyspnea in infancy. Arnheim has reviewed eight cases reported in the literature in which the patient survived operation. At the other end of the scale, mild degrees of eventration may not be discovered until old age and may be either congenital or follow phrenic nerve paralysis.

Fluoroscopic examination will show a high level of one side of the diaphragm, with restricted motion. Paradoxical motion does not occur unless there is phrenic nerve paralysis.

Whether or not operation is necessary depends on the patient's pulmonary symptoms. If necessary, plication is carried out, either by the abdominal or by the thoracic approach. Intestinal obstruction does not occur, because the diaphragm is intact.

7. Interstitial Hernia

Interstitial hernias lie between the layers of the abdominal wall. They are divided into four groups. In the *properitoneal hernia* the sac lies between the peritoneum and the transversalis fascia. In the *intramuscular hernia* the sac is found between two of the muscle layers of the abdominal wall. In the *inguinosuperficial hernia* the sac lies between the external oblique aponeurosis and the skin and is nearly always associated with an undescended testicle. The *external supravesical hernia* is the rarest of these types.

The methods of diagnosis and treatment and the incidence of strangulation are similar to those of inguinal hernia.

8. Prevesical Hernia

Prevesical hernias are found in the supravesical fossa, which is between the obliterated hypogastric arteries, inferior to the bladder and superior to the symphysis. They are distinguished by a great variety of terms describing the same entity, as shown by Warvi and Orr in their complete review. These authors found 34 reported cases, with a mortality rate of 44 per cent, due to high incidence of strangulation.

9. Lumbar Hernia

Lumbar hernias appear through the triangular area banded by the latissimus dorsi, the external oblique, and the crest of the ileum (Petit's triangle) or through the superior lumbar triangle, which is slightly above and anterior. Watson collected 186 cases of lumbar hernia from the literature in 1946; strangulation occurred in only 15 per cent. He ascribed this low incidence of strangulation to the large size of the ring and neck of the sac.

When repair is undertaken, care is necessary during the exposure, because in many instances no sac is present (Fig. 100). If a sac is found it is excised and the neck closed. Repair of the defect, when it is large, may require strips of fascia lata, or a flap of fascia lata may be cut and swung upward from just below the iliac crest.

10. Obturator Hernia

Obturator hernias leave the pelvis through the obturator foramen. They are not uncommon, since Watson collected 442 cases in 1946, while Harper and Holt, in 1956, stated that 463 cases had been reported in the literature. They are six times commoner in women than in men. Previous pregnancies, old age, and emaciation are important predisposing causes. Bilateral hernias occur.

Obturator hernias should be diagnosed preoperatively, though they usually are incorrectly called femoral hernias. An important symptom is pain along the course of the obturator nerve (the Howship-Romberg sign). This pain occurs down the inner side of the thigh, sometimes as far down as the foot, in

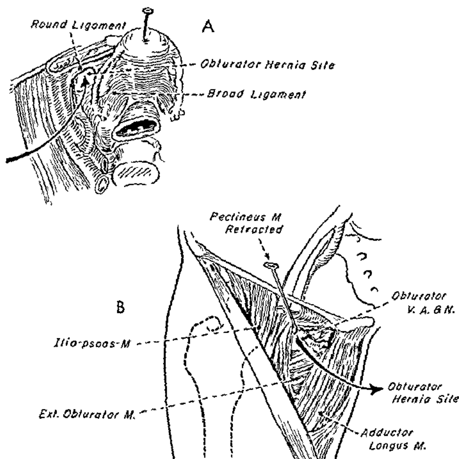
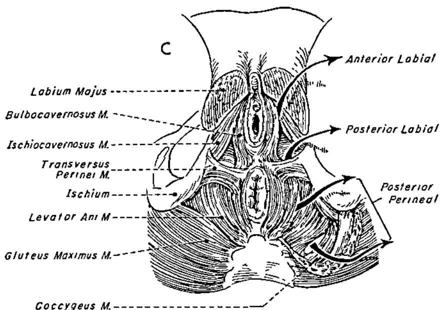
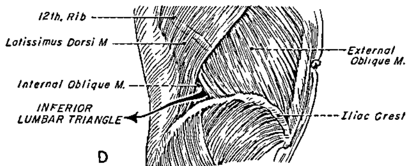


Fig. 100.—Anatomy of rare extra-abdominal hernias. **A**, obturator hernia seen from within pelvis. The hernial orifice is below the round ligament. **B**, obturator hernia—external anatomy (**continued**).

over half of the cases. To demonstrate the hernia the patient lies on his back with thigh flexed, adducted, and externally rotated; a point of tenderness should be elicited at the region of the obturator foramen, which lies about an inch below and behind the femoral canal. At times this area is palpated more satisfactorily through the vaginal or rectal wall.

Operation is carried out through either the abdominal, the external, or the combined route. The incidence of strangulation is high, and whenever obstruc-





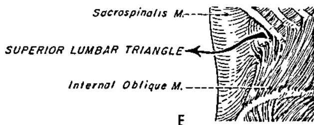


Fig. 100 (cont.).—**C**, perineal hernia **D**, inferior lumbar hernia. **E**, superior lumbar hernia **(continued)**.

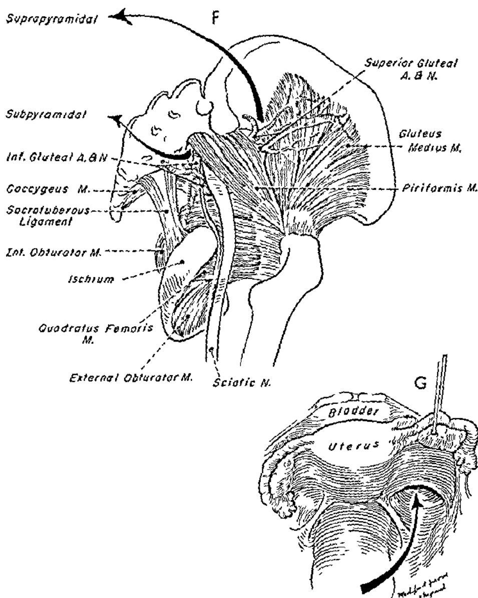


Fig. 100 (cont.).—*F*, sciatic hernia. Bony pelvis is indicated by dotted lines. Gluteus maximus lies superficial to hernia and is not shown. Two commonest types of sciatic hernia are illustrated. Suprapyramidal emerges above pyriformis muscle and subpyramidal below it. *G*, sciatic hernia. Internal appearance of hernial orifice as it appears behind broad end in front of uterosacral ligament.

tion is present, the abdominal route is essential. Extreme care must be taken to avoid the obturator artery and nerve. This is difficult because the foramen is small and the walls unyielding. The artery usually lies behind and lateral to the sac, though it may lie anteriorly, and occasionally an arterial ring will surround the hernial sac. The nerve usually is located lateral to the sac and above the artery.

If the external route is chosen or is necessary for reduction, a vertical incision is made 3.5 cm. medial to the femoral artery or halfway between artery and pubic spine. The adductor longus is dissected and retracted inward and the pectineus outward. The sac is identified between these two muscles. After the sac has been mobilized and opened, if the intestine cannot be reduced, the internal obturator membrane must be cut. The artery must be located before this is done to avert hemorrhage. After viability of the intestine has been ascertained, the obturator canal must be closed by fascia, by a muscle flap from the pectineus, or by tantalum mesh.

11. Sciatic Hernia

Sciatic hernias usually appear through the greater sciatic foramen above the pyriformis, though they may appear below the pyriformis or through the lesser sciatic notch. According to Watson, these are the rarest of all external hernias; he was able to find only 35 reported cases in 1946.

The hernias are small, but their incidence of strangulation is high. A point of localized tenderness can sometimes be found in the sacrosciatic notch. To find this point a line is drawn from the posterior superior iliac spine to the greater trochanter of the femur; the notch lies just below the junction of the upper and middle thirds of the line (Fig. 100).

If such a lesion is suspected it should be exposed by an abdominal incision. A posterior approach has been employed, but the exposure is difficult and there is danger of damaging the gluteal artery or sacral nerves. The hernial sac will be found just lateral to the rectum and, in the female, behind the broad ligament.

12. Perineal Hernia

Perineal hernias appear at various sites through the pelvic outlet. A number of varieties have been described, of which the most important are (1) hernias into a deep pouch of Douglas, (2) anterior perineal hernias, and (3) posterior perineal hernias. Small intestine is usually found in the first and third types and bladder in the second. These hernias are nearly always small, and strangulation is uncommon (Fig. 100).

Repair is difficult through a perineal approach alone, while in the presence

of intestinal obstruction an abdominal incision is essential. A combined abdominoperineal operation will give the best exposure and the strongest repair.

13. Richter's Hernia

Richter's hernia, or partial enterocele, is a strangulated hernia in which only part of the circumference of the intestine is caught in the hernial ring. The name is due to the careful description of this type of hernia given by Richter in 1785. Though this hernia is common, little attention is given to it in the literature. Keynes, who contributed a recent paper, could find no other references to it in the literature in the past 25 years. This is a serious hernia because gangrene of the constricted area occurs commonly. Such gangrene may lead to perforation, abscess, or fistula formation in the absence of complete intestinal obstruction.

Diagnosis is difficult. Despite care on examination, only about one-half can be detected on physical examination. A slight swelling or localized tenderness at one of the hernial apertures associated with symptoms of partial obstruction indicates exploration. The inguinal, femoral, and obturator areas should be examined with special care.

Operation should be carried out as soon as possible. It may be necessary to open the peritoneal cavity to free intestine sufficiently. While a tiny gangrenous area may be excised and the intestine closed, some patients will require *resection and anastomosis.*

14. Littre's Hernia

Littre's is a hernia that contains only a Meckel's diverticulum. A Meckel's diverticulum may be present in other hernias that contain ileum and omentum as well. Strangulation is rare, and partial intestinal obstruction is the rule. In a series of cases collected by Watson, in 1946, 135 were inguinal, 54 femoral, 32 umbilical, one ventral, and two sciatic.

At operation the intestine should be withdrawn and carefully examined. The diverticulum must be excised and closure effected so that the lumen of the intestine is not compromised. Resection and anastomosis of the diverticula-bearing portion of the intestine may be necessary.

15. Appendiceal Hernia

The appendix is present *in 1 to 1.5 per cent of all hernias* containing abdominal viscera, according to Watson. Fortunately intestinal obstruction is rarely a complication even when acute appendicitis occurs in the hernial sac.

B. INTRA-ABDOMINAL HERNIAS

Intra-abdominal hernias differ from the external type in that the normal outline of the peritoneal cavity is intact, but the gut forces its way into anomalous fossae, through foramina or anomalous openings, or through traps left by the surgeon. They are impossible to identify accurately before laparotomy, although they may be expected as postoperative sequelae to certain operations. With the exception of postoperative hernias, all are rare (Fig. 101).

Hansmann and Morton collected 467 cases of intra-abdominal hernias from the literature. (*See* Table 10.)

TABLE 10.—FREQUENCY OF INTRA-ABDOMINAL HERNIA, DATA OF HANSMANN AND MORTON

Left paraduodenal	138
Transverse mesocolon	60
Right paraduodenal	47
Mesenteric	38
Foramen of Winslow	37
Paracecal	31
Intersigmoid	28
Broad ligament	18
Ileoappendicular	16
Ileocolic	14
Prevesical	13
Inferior duodenal	5
Great omentum	5
Ascending mesocolon	4
Miscellaneous	13
Total	467

1. HERNIAS INTO ANOMALOUS FOSSAE

Hernias into anomalous fossae include paraduodenal, pericecal, and intersigmoidal hernias. Foramen of Winslow hernias are also put in this group; though the foramen is constantly present, it normally is an open space.

Paraduodenal hernias include over half of intra-abdominal hernias (Fig. 103). A complex system of fossae have been observed about the duodenum, due to different types of incomplete fixation of the mesenteries of small intestine and colon. Moynihan described nine such fossae. The anatomic features are reported in his monograph.

In general terms, these hernias may be classified as either left or right paraduodenal (or mesentericoparietal) hernias. When the greater part of the small bowel is enclosed in the sac, the initial view of the peritoneal cavity is a confusing one indeed. At first, only a small section of intestine will be visible, and the peritoneal cavity will seem to be absent. The surgeon must be very careful with his dissection, to be certain that no irreparable damage is done to the blood supply of the gut (Fig. 102).

of intestinal obstruction an abdominal incision is essential. A combined abdominoperineal operation will give the best exposure and the strongest repair.

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At operation the intestine should be withdrawn and carefully examined. The diverticulum must be excised and closure effected so that the lumen of the intestine is not compromised. Resection and anastomosis of the diverticula-bearing portion of the intestine may be necessary.

15. Appendiceal Hernia

The appendix is present in 1 to 1.5 per cent of all hernias containing abdominal viscera, according to Watson. Fortunately intestinal obstruction is rarely a complication even when acute appendicitis occurs in the hernial sac.

The anterior wall of the sac is formed by the mesocolon. When the sac is on the left, as is by far the most common occurrence, the mass of intestine is to the left of the mid-line, the opening is directed toward the right, and the inferior mesenteric vein usually courses along the anteromedial margin of the sac. When the sac is on the right, the incarcerated intestines are found on the right, the opening of the sac is directed toward the left, and the superior mesenteric artery usually runs along the anteromedial margin of the sac.

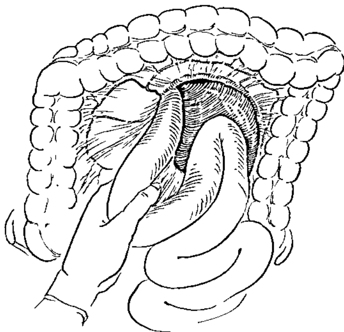
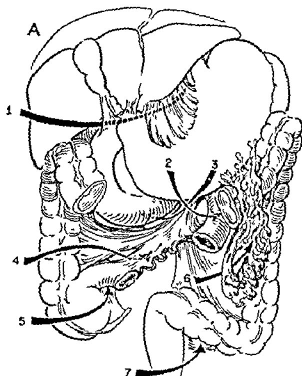


Fig. 102.—Left paraduodenal hernia. Jejunum has been withdrawn from the sac. Inferior mesenteric vein usually runs along anterior margin of sac.

These hernias, fortunately, rarely contain gangrenous bowel. They sometimes can be diagnosed in the absence of acute obstruction by the oral administration of barium, which will outline a globular collection of barium-filled loops just distal and lateral to the ligament of Treitz. They are treated either prophylactically, or, in the presence of obstruction, by withdrawal of the loops of the intestine and careful closure of the neck of the sac.

Pericecal hernias involve four fossae that have been described about the cecum; these are the ileocolic, ileocecal, retrocecal, and retroappendicular. Hernias in this region are rare. Langley, in 1935, was able to find only 26 cases in which this type of hernia caused intestinal obstruction.

A sigmoid fossa is nearly always present in infants, but it becomes less frequent with age, owing to obstruction by adhesions. It lies between the sig-



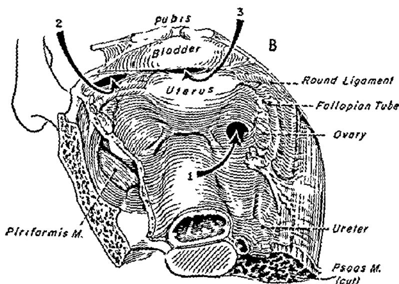


Fig. 101.—Intra-abdominal hernias. A, in upper abdomen: 1, foramen of Winslow; 2, left paraduodenal; 3, right paraduodenal; 4, transmesenteric; 5, paracecal; 6, omental defect; 7, intersigmoid. B, in pelvis: 1, defect in broad ligament; 2, Olshausen suspension; 3, internal supravesical.

omentum should be opened and the distended intestine decompressed. Thereafter, the intestine can be withdrawn without damage to the portal vein, hepatic artery, or common duct.

2. Hernias through Anomalous Openings

The second class of intra-abdominal hernias includes hernias through anomalous openings in the omentum, mesentery, or broad ligament.

The omentum occasionally contains small apertures through which the small intestine may herniate and strangulate. *Omental defect hernias* may be found in the absence of any previous operation. If rents occur in the omentum at the time of any laparotomy they should be closed to prevent this occurrence.

Congenital holes may occur through the gut mesentery. Hernias through such defects are known as *transmesenteric hernias.* They occur most frequently in the mesentery of the terminal ileum between the last ileal and the ileocolic arteries. Other defects may be secondary to trauma or to operative procedures. May and Brintnall found 86 reported cases and believe that the present operative mortality for this lesion is about 35 per cent.

Hernias into the broad ligament are rare and occur chiefly in women between 20 and 50 years of age, particularly those who have had one or more children. The defect in the ligament may be congenital or postoperative. Collected reviews of reported cases have been made by Bowles and by Goode and Newbern.

Postoperative traps following pelvic operations such as suspension of the uterus by the Olshausen, Baldy-Webster, or other technique are common and may lead to strangulation of a loop of intestine. Fortunately these operations are now becoming less common, so that this serious complication is rare. Baron found 45 reported strangulations of intestine from broad ligament defects; 17 of them followed a Baldy-Webster suspension. When operation is done, the abnormal opening in the broad ligament or open trap should be closed.

3. Hernias due to Postoperative Abnormalities

The surgeon is the most potent agent in the production of intra-abdominal hernias. Through a variety of operative maneuvers he produces stomas, points of fixation, and traps. Intestine may herniate into such apertures and produce a serious type of obstruction that usually is strangulating and may occur very early after the primary operation that produced the abnormality.

In the approximate order of frequency such internal hernias are encountered after colostomy (following combined abdominoperineal excision of the rectum); *after terminal ileostomy (for ulcerative colitis); after* various op-

moid colon and the parietal peritoneum and can be exposed by drawing the sigmoid upward and to the left. The anterior wall of the fossa contains the sigmoid vessels, and the posterior lies upon the common iliac artery and the ureter. *Intersigmoid fossa hernias* also are very rare. Harrison and Cheek, in 1951, discovered 24 cases in the literature and reported one of their own.

Hernias of the foramen of Winslow are rare, less than 70 having been reported before 1949, according to Venner. The hernia occurs when small in-

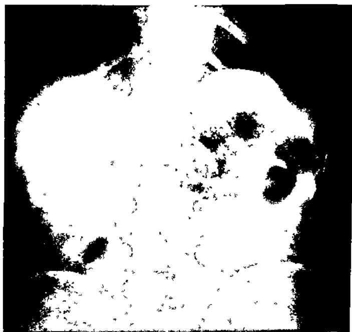


Fig. 103.—Left paraduodenal hernia. Collection of gas-filled loops of intestine localized in left upper quadrant is characteristic of left paraduodenal hernia.

testine forces its way through the foramen, passing from right to left. Very rarely, after operations that have opened the greater omentum, eliminating the anterior wall of the lesser omental sac, the intestine may pass behind the stomach and through the foramen from left to right. This situation has been observed in our hospital after colectomy for ulcerative colitis.

The small bowel is always present in the hernia, but sections of the mobile colon may be dragged along with it. Usually a chronic type of obstruction develops that is followed by acute obstruction. The preoperative diagnosis has been made in a number of cases by the oral administration of barium. In the ordinary type of hernia, barium will demonstrate the stomach pushed to the left by a globular mass of gas-filled intestinal loops.

Operative reduction of the hernia usually is difficult. The gastrohepatic

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Obstruction by External Compression

THE LUMEN OF THE SMALL intestine may be occluded by pressure from extraluminal viscera or masses. By far the commonest type of lesion causing such occlusion is carcinomatosis. Intraperitoneal abscesses are not uncommon, but the other lesions discussed in this section rarely produce obstruction.

A. CARCINOMATOSIS

Carcinomatosis has become a progressively more common cause of intestinal obstruction and now accounts for nearly 10 per cent of all cases at the Massachusetts General Hospital. Since it is a particularly unfavorable type to treat, the mortaliy remains high.

Though the obstruction may involve either the intestine, the colon, or both, usually the small intestine is obstructed either completely or partially by numerous masses of cancer. If the colon alone is affected, as it may be by extensive metastases to the pouch of Douglas, some palliation from the intestinal cramps is furnished by colostomy. Such benefit may persist for several months. When the small intestine is involved, it is only rarely that an enteroanastomosis can be made about a single point of obstruction; exploration, therefore, often must be terminated as soon as it is ascertained that the situation is hopeless.

A great deal has been written about the surgical excision of widespread metastatic masses of cancer from the peritoneal cavity, with occasional survivals for two to three years. This plucking of masses of metastatic cancer has, in our experience at the Massachusetts General Hospital, nearly always been futile except when the cancer arose from the ovaries. With this type of carcinoma, we believe every attempt should be made to remove the ovaries and as much of the metastatic tumor as possible. Under such circumstances the residual tumor may become more responsive to X ray treatment. Fur-

erations on the colon or intestine in which traps have been left in the mesentery or behind lateral anastomoses; after gastroenterostomy (particularly after antecolic anastomosis), and after fixation of a loop of small intestine to the abdominal wall by ileostomy or jejunostomy.

When obstruction occurs from these causes soon after the original operation which produced them, the situation is serious because the tendency is to treat all postoperative obstructions by intestinal tube decompression. This can be dangerous or fatal when applied to a strangulated loop. The problem of postoperative obstruction will be discussed in more detail in a following chapter.

The situation is not so difficult to recognize when the patient returns several months or years after the original operation. The signs of obstruction are then clear. In the presence of any colostomy or ileostomy incision the surgeon must entertain the diagnosis of strangulating obstruction even when the signs are not definite, and operation should not be delayed. The operative procedure must include not only the relief of the obstruction but the closure of any traps or lysis of any adherent bowel to eliminate the possibility of recurrence.

Obviously, prevention of these catastrophes by attention to certain details at the primary operation is essential. Particularly careful closure of traps lateral to all colostomies or ileostomies should be routine.

ileostomy for ulcerative colitis, pregnancy led to obstruction from mechanical pressure on the ileum at about the fifth month.

E. RETAINED FOREIGN BODIES

While retained foreign bodies in the abdominal cavity now are rare, they must be considered as a possible cause of obstruction in patients who have had a previous abdominal operation.

Crossen and Crossen were able to collect and report 400 cases by 1940. A gauze sponge is by far the commonest retained foreign body. A summary of 250 of their cases in which a sponge was found, as recorded by Fair, indicates that intestinal obstruction actually does not become a problem until a long period has passed. A wrong sponge count, persistent fever, a deep mass, persistent fistula or sinus, or partial extrusion of the foreign body through the bowel, bladder, or incision frequently led to re-exploration within three months. While half of the retained foreign bodies were not recognized until five years later, most of them had produced symptoms of intestinal disturbance or obstruction, persistent fever, or a tender mass before that time.

Sponges tend to become inextricably enmeshed with the intestine, so that intestinal resection is often necessary when they are removed. Various degrees of encapsulation with fibrous tissue and suppuration occur. Calcification is unusual unless there is communication with bowel or bladder. In some instances, complete disintegration of the sponge occurs.

F. SUPERIOR MESENTERIC ARTERY COMPRESSION OF DUODENUM

The syndrome of a dilated duodenum with clinical evidence of obstruction was for many years ascribed to a compression of the distal duodenum at the ligament of Treitz by the superior mesenteric artery. It is now known that such a lesion is very rare. A dilated duodenum may be part of a generalized deficiency state, may be due to periduodenal adhesions, or may occur in congenital absence of ganglion cells in the myenteric plexus. If the only cause for the obstruction actually is arterial compression, excellent results follow a duodenojejunostomy.

G. ANNULAR PANCREAS OBSTRUCTING DUODENUM

Duodenal obstruction due to an annular pancreas, although relatively rare, is being observed more frequently. Excellent reviews have been presented by Kiesewetter and Koop and by Tendler and Ciuti. The latter authors estimate that about 90 cases have been reported and that 60 patients have had surgery.

thermore, since ovarian cancer is sometimes subject to spontaneous regression, the surgeon has more optimism in dealing with it than with some other types of tumor.

The situation is somewhat different if a single or only a few isolated masses of metastatic cancer are present in the peritoneal cavity. Extensive resection is then possible, and even though the entire mass of cancer cannot be removed, it is eminently worthwhile. Every experienced surgeon will recall patients with relative long survivals after such procedures.

The surgeon is often faced with the problem of irremovable metastatic disease arising from a tumor of the gastrointestinal tract that in itself is removable. In general terms, if the primary tumor can be removed without too much difficulty it should be removed, since this may prevent the development of obstructive symptoms at a later date.

B. INTRAPERITONEAL ABSCESSES

Abscesses may produce obstruction either by direct compression or by angulation of the bowel by plastic adhesions. They are most likely to cause trouble when located in the pelvis, because of the rigidity of its walls. Appendicitis, diverticulitis, and salpingitis are the usual causes. Rupture of the gallbladder may produce obstruction by a pericholecystic abscess. Blain and Harkins found that of 41 gallbladder perforations 11 were associated with intestinal obstruction, five with gallstone ileus, and in six with other mechanisms. Usually drainage of the abscess will relieve the obstruction, though at times lysis of plastic adhesions also will be necessary.

C. ADJACENT TUMORS, BENIGN OR MALIGNANT

A variety of tumors originating from the female pelvic organs can produce obstruction. Large renal tumors or hydronephrosis may compress the duodenum or right colon. Lymphomas primary in the mesenteric lymph nodes, mesenteric cysts, and presacral cysts furnish other examples of this type of obstruction.

D. PREGNANCY

Pregnancy apparently may occasionally give rise to complete intestinal obstruction in the absence of any intrinsic lesion of the bowel. However, the "physiologic" obstruction produced by pregnancy is incomplete, and whenever complete obstruction occurs, it should be assumed that a specific cause for it other than pregnancy is involved. After some operations, however, pregnancy will enhance the chances of obstruction. At the Massachusetts General Hospital in the past few years, in two instances, several years after

22

Megacolon

MEGACOLON INCLUDES TWO TYPES of abnormalities. The congenital type of the disease, which is by far the commoner, manifests itself first in infancy or childhood and is known universally as Hirschsprung's disease. The acquired types develop later in life and do not demonstrate the typical agenesis of the myenteric plexus seen in Hirschsprung's disease.

The cause of congenital megacolon remained a mystery for nearly half a century after Hirschsprung first described the disease. The historical development of the modern theory of its etiology was traced by Lee and Bebb. No progress was made in therapy, however, until Whitehouse and Kernohan summarized the existing knowledge of the disease in 1948 and, in a careful study of 11 cases, found that the myenteric plexus was absent from the distal colon or rectum in all cases. Hiatt, by balloon techniques, proved that peristalsis in this segment was feeble, irregular, and ineffective. Swenson and coworkers shortly thereafter proved the validity of this thesis by showing that excision of the abnormal area resulted in cure.

Sufficient studies are not available to disclose whether or not myenteric plexus is abnormal in every patient with secondary megacolon. In a few cases studied by biopsies of the mucosa at different levels, the ganglia seemed to be normal in appearance and number. Certainly there are some cases in which no cause for an acquired megacolon can be found. In others, strictures of the lower rectum or colon, repeated attacks of volvulus, or repeated episodes of fecal impaction account for the secondary dilatation above this point. Raia, in Brazil, has noted acquired megacolon secondary to vitamin deficiency and progressive degeneration of the myenteric plexus.

A. CONGENITAL MEGACOLON

SYMPTOMS AND SIGNS.—Queerly enough, 90 per cent of the cases occur in males. In most instances symptoms appear within the first few days of life.

While an annular pancreas usually is encountered in infants, it may be observed in adult life. The history suggests pyloric obstruction, since the common duct enters the duodenum beneath the ring. However, X ray examination demonstrates the dilation of the stomach and proximal duodenum and, on barium administration, the typical obstructing ring is shown.

Although section of the ring would appear to be the best operation, this actually has been dangerous, since aberrent pancreatic ducts may be cut. Secondary obstruction due to fibrosis may also follow complete section of the ring. Since there is also a severe duodenal stenosis in some infants, section of the ring alone would be ineffective. Hence, it is better to perform a duodenojejunostomy above the obstruction. A gastric resection may be an easier and more satisfactory operation in adults. This point of view has been supported by Sanford's analysis. In 35 pediatric cases he found duodenojejunostomy the treatment of choice, but in 38 adults there was a 34 per cent incidence of peptic ulcer, making gastric resection the treatment of choice.

H. WANDERING SPLEEN

Wandering spleens may be found in the pelvis, and because of compression of the small intestine by the pedicle of the spleen, they may produce obstruction. Splenectomy is indicated. The spleen may also produce obstruction from another mechanism. After traumatic rupture, fragments may be seeded in the peritoneal cavity. As they enlarge, they may angulate the intestine, so that this disease of splenosis may be manifested by intestinal obstruction.

pathologist to study the ganglion cells satisfactorily. Quinby has found this method more satisfactory than sigmoidoscopic biopsy.

TREATMENT.—A few infants with mild symptoms can be treated by medical measures, the abdominal distention being controlled by a low-residue diet, frequent cathartics, and enemas; however, all with severe symptoms of



Fig. 104.—Hirschsprung's disease. Child 5, had mongolism and died soon after this picture was taken. Note huge abdomen occupied nearly entirely by megacolon, which has been partially filled with barium. Spastic area in lower rectum is shown clearly.

obstruction require operation. Acute obstruction or subacute symptoms persisting for a week should be treated by a decompressive procedure. It is assumed that the definitive operation will consist of the excision of the aganglionic segment of the colon, with a pull-through anastomosis made by Swenson's technique. First-stage operations that decompress the colon are advantageous in infants, since they not only relieve the acute obstruction, but also aid in the preoperative preparation of the colon and allow deferment of the resection until at least the sixth month of life or, preferably, for two or three years, when it is technically easier to perform. Gross emphasized the necessity of administering a barium enema to demonstrate the

The disease may be severe at its onset and may first be demonstrated by an attack of acute colonic obstruction. In some instances, a slowly progressive enlargement of the abdomen is noted, with intermittent minor attacks of obstruction. The abdomen gradually becomes hugely distended. Peristaltic waves may be palpable along the course of the colon, along with large masses of fecal material. At the time of acute obstruction, high-pitched peristalsis, cramps, and vomiting occur. Rectal examination is often negative. Though an area of spasm is seen regularly by X ray in the rectum at the level of the peritoneal floor, this cannot always be identified by the examining finger. Gradually, unless the child's condition is corrected, there is interference with nutrition and respiration. Occasionally, nutritional disturbances so overshadow the intestinal symptoms that the diagnosis of megacolon is made with difficulty.

In the newborn infant the diagnosis may not be easy. Klein and Scarborough noted that failure to make the correct diagnosis is the most important factor that has contributed to the high mortality. The diagnosis must be considered in infants with symptoms or signs of low intestinal obstruction, particularly when no mechanical block is demonstrated radiologically. An abdominal film will show fecal shadows in the colon, but the infant vomits, passes no stools, and becomes distended.

Another syndrome in the newborn that deserves emphasis is the combination of vomiting with minimal distention, either clinically or by X ray. This clinical picture of high obstruction has been observed by Quinby twice in the past few months.

The X ray examination consists of a scout plate and a careful barium enema. On the plain film enormous distention of the colon and intestine may be seen. The barium enema should be used with great care, since the introduction of a large amount of barium into the distended colon is unnecessary and dangerous. An attempt should be made to demonstrate the characteristic areas of spasm in the lower portion of the rectum. Little barium should be inserted thereafter, and, at the conclusion of the procedure, enemas should be used to evacuate the colon. Evacuation of the colon is poor, and, despite care, barium is usually retained in the colon for at least 24 hours after examination (Fig. 104).

When the diagnosis is not clear and is considered to be essential, removal of a biopsy specimen of the rectal mucosa through the area of spasm must be done. This may not be an easy maneuver in infants. It requires excision of a segment about 1 cm. in diameter through the full thickness of the rectal wall. Removal of the specimen is done under general anesthesia and direct vision in the posterior wall, so that there will be no danger of intraperitoneal perforation. Unless an adequate section is taken, it will be impossible for the

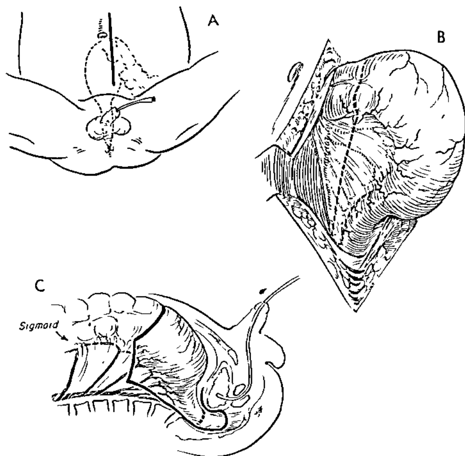


Fig. 105.—Swenson's operation for megacolon. **A,** child is placed on operating table with legs flexed so that entire abdomen and perineum can be prepared. **B,** sigmoid is to be mobilized as shown by dotted lines. **C,** sagittal view of extent of dissection. Dissection is kept close to wall of colon. Upper end of resected sigmoid must contain normal ganglion cells, as determined by frozen section. If these are not shown, additional section of sigmoid must be resected. Upper end of sigmoid then is closed by suture (**continued**).

perineum are accessible. The steps in the operation are shown in Figure 105.

Patients have been improved spectacularly by operation. Out of 70 operated on in the Children's Hospital to Dec. 1, 1951, two died, mild strictures developed in four, two required frequent enemas, one had a secondary resection to remove more bowel, and six had to have occasional enemas. The others were asymptomatic. This complete relief of symptoms in over 90 per cent of the patients is an amazing record, especially in view of the fact that the disease was regarded as essentially incurable 10 years ago. In a

area of rectal spasm before a colostomy, for otherwise the entire colon collapses and the spastic area can no longer be identified. However, if the child is 6 months of age or older, it is best, if possible, to prepare the colon and do the resection without preliminary decompression.

A hazard of protracted treatment by enemas has been noted by Swenson. When these patients finally come to surgery colostomy diarrhea may follow and be a very serious or even fatal complication. Patients in whom the diagnosis was made and colostomy done at an early date have had virtually no trouble from this diarrhea.

A wide variety of decompressive operations have been employed by various surgeons. If cecostomy is done, the cecum should be partially withdrawn and sutured to the skin. This is a serious operation in infants because it may lead to severe diarrhea. Tube cecostomy will tide the patient over an acute episode, but the result is likely to last too short a time to be of value. A completely defunctioning colostomy is far better than cecostomy. The colostomy incision has been placed by different surgeons in all portions of the colon. Koop found that a transverse colostomy was not difficult to control. Swenson prefers a sigmoid colostomy using the dilated segment and resects the stoma at the time of the definitive operation. This procedure allows great mobility of the colon at the time of the second operation and meanwhile reduces the loss of fluids and electrolytes, which can be fatal in an infant with a stoma at a more proximal level.

The definitive treatment of megacolon was, for the first time, placed upon a sound basis by Swenson. Before that time emphasis was placed either upon sympathectomy, which was never effective, or upon an excision of the dilated segment of colon, which was followed sooner or later by recurrence. He showed that it is necessary to excise the entire aganglionic segment in the lower rectum in order to effect cure. Studies have demonstrated that the aganglionic segment nearly always begins in the lowermost portion of rectal mucosa, at the mucocutaneous level, and extends upward for a variable distance into the colon. In 90 per cent of the cases the defect stops in the lower sigmoid colon. Among 150 cases, Swenson and Fisher found that the entire colon was deficient in ganglion cells in two. It cannot be expected, therefore, that the entire aganglionic segment can be excised by a low anterior resection; the use of a combined abdominoperineal resection, with the pull-through technique, is required to assure a normal nerve supply down to the anus.

Careful attention must be given to the preoperative preparation of the colon; it must be cleaned out as thoroughly as possible by numerous saline enemas. Water enemas may lead to water intoxication. At the time of operation the child is placed on the table in such a position that both abdomen and

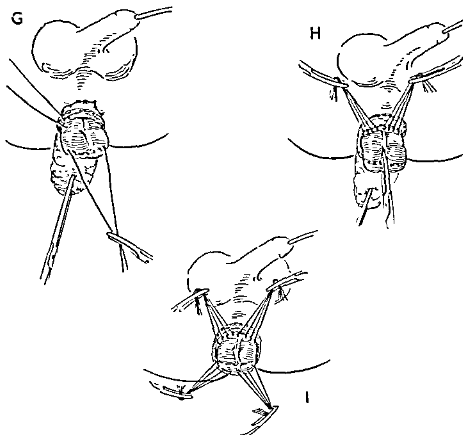


Fig. 105 (cont.).—**G,** anterior wall of sigmoid is sutured to anterior rectal wall with interrupted silk sutures. **H,** completion of anterior row of sutures. **I,** posterior row of *sutures has been placed. Closed end of sigmoid now is amputated* **(continued).**

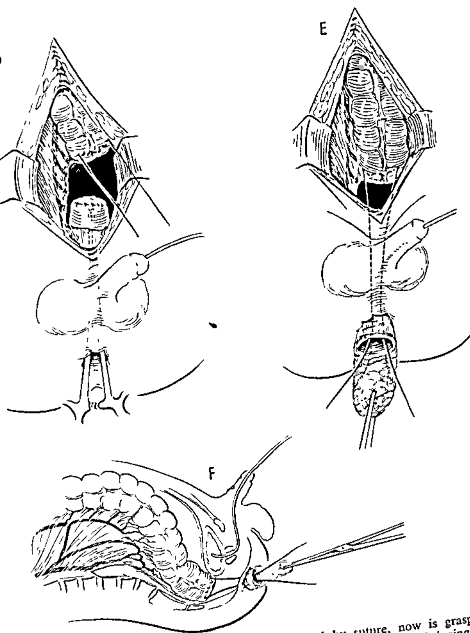


Fig. 105 (cont.).—D, Lower end, also closed by suture, now is grasped by clamp introduced through dilated anus. Clamp is then withdrawn, bringing upper end of rectal stump out through anus. **E,** anterior wall of everted rectum is incised as close to anus as possible. Upper sigmoid is now withdrawn through this incision. **F,** sagittal view of step **E (continued).**

later study reported in 1957, Swenson found there were only 5 unsatisfactory results in the 194 survivors of 200 resections.

B. OTHER DISEASES DUE TO CONGENITAL AGANGLIONOSIS

Megaesophagus, megaduodenum, megajejunum, and megaileum develop because of a localized lack of development of ganglion cells in these sections of the gastrointestinal tract. In achalasia of the esophagus, the lesion is chiefly localized to the area of the cardia.

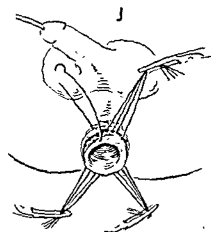
Congenital megaduodenum is a rare lesion but far commoner than aganglionosis in any other section of the small intestine. Barnett and Wall collected 35 cases from the literature. They believe many cases of so-called superior mesenteric artery ileus are due to this cause. Epigastric discomfort, nausea, vomiting, and weight loss are the most important symptoms. Barium studies show a greatly dilated duodenum, and no cause for obstruction can be demonstrated at laparotomy. Duodenojejunostomy is considered to be the treatment of choice.

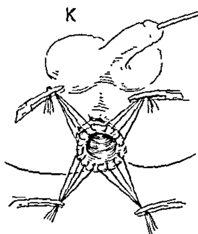
The lack of development of ganglion cells is not limited to the intestinal tract. Since megaloureters occur in a number of patients with Hirschsprung's disease, the urinary tract should be investigated in every patient who has congenital megacolon.

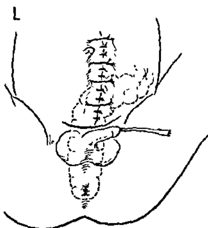
C. ACQUIRED MEGACOLON

Cases in which megacolon develops later in life are said to be instances of acquired megacolon. These include a heterogeneous group of cases. Strictures of the rectum or colon, repeated episodes of fecal impaction, or repeated attacks of volvulus may produce secondary dilatation proximal to the point of obstruction. It is possible that in some instances a mild form of congenital megacolon may cause symptoms first in late childhood or early adult life, though this view is not accepted by all. In some cases the etiology is a complete mystery; such a case is illustrated in Figure 106. The patient had no known cause for the megacolon, and biopsies of the rectum at various levels all showed normal ganglion cells.

The acquired megacolon observed in Brazil is a particularly interesting type. In 205 cases reported by Raia evidence was presented that normal ganglion cells will degenerate in adult life probably due to vitamin B deficiency. Other diseases in which aganglionosis is noted were not uncommonly associated with the megacolon. Thus megaesophagus was encountered in 69 cases, achalasia of the pylorus in 7, megaduodenum in 3, megajejunum in 2 and megaileum in 2. In the colon, the disease is most prominent in the rectum and less well marked in the proximal portions. Microscopically, vacuoli-







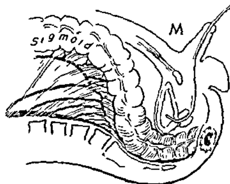


Fig. 105 (cont.).—J, inner row of sutures has been started. K, completion of inner row of interrupted sutures. L and M, peritoneum has been closed about sigmoid, abdominal incision has been closed. Anastomosis has been inverted into anus and is no longer visible.

23

Ileus—Paralytic, Colonic, and Spastic

A. PARALYTIC ILEUS

PARALYTIC ILEUS IS A CONDITION in which there is no organic obstruction of the intestinal tract, but, because of a nearly complete lack of intestinal peristalsis, forward propulsion of the intestinal contents ceases. The term "ileus" often erroneously is used as a synonym. A more accurate term is that of Wangensteen, "inhibition ileus", since peristalsis is not completely paralyzed. However, the older, common term will be used here.

CAUSES.—Paralytic ileus of a mild degree is extremely common, since it occurs after every abdominal operation. Usually effective peristalsis returns in two or three days, but in the presence of peritonitis, the ileus tends to persist for a longer period. It also is common in association with many other lesions, including retroperitoneal hemorrhage; fractures of the vertebrae; renal colic; fractured ribs; pulmonary lesions, such as pneumonia or pneumothorax; torsion of the ovary, testicle, or omentum; diseases of the central nervous system, and severe acute infections (Fig. 107).

The fundamental cause of paralytic ileus, common to this great variety of lesions, appears to be overactivity of the sympathetic nerves. A differential spinal anesthesia, done by the technique described by Sarnoff and Arrowwood, will block the sympathetics and sometimes produce rapid deflation of a distended bowel. A severe paralytic ileus also sometimes follows the use of autonomic blocking agents, such as hexamethonium; it has been encountered not infrequently when this drug has been used as a treatment for hypertension.

It is interesting to speculate on the unknown chemical causes of paralytic ileus. Certain agents appear to produce such an ileus and may act in the same fashion as hexamethonium. For example, Roantree described a serious form of paralytic ileus that developed in previously healthy persons. It occurred

zation of the nerve cells, destruction of nuclei, and a discrete lymphocytic infiltrate about the plexuses was observed.

In his series, 41 patients were treated by sphincterectomy and 90 by rectosigmoidectomy. Of the various sphincterectomies that were tried, tempo-

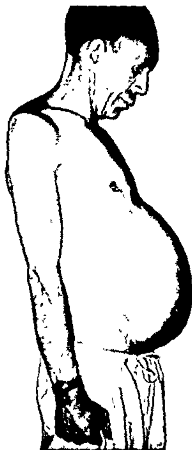


Fig. 106.—Acquired megacolon. Man complained of severe abdominal distention and constipation for many years. Ganglion cells normal in rectal biopsy specimen and *in resected colon. Subtotal colectomy carried out with relief.*

rary satisfactory results were obtained, but the effects were transitory. The best method by far was found to be rectosigmoidectomy performed in 1, 2 or 3 stages. A diet rich in vitamins was given postoperatively.

In all of the cases of acquired megacolon, repeated episodes of obstruction are the rule. If an etiologic agent can be demonstrated, correction of it is indicated. In some instances a partial or subtotal colectomy will be required, provided biopsies show normal ganglion cells in the rectum.

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in Mysore State, south India, in the poorest section of the population, which used millet as the staple article of diet. Leithauser described six cases of ileus that he believed were due to thiamine chloride deficiency.

Electrolyte imbalances are also important causes of paralytic ileus. Hypochloremic alkalosis, accompanied by hypokaliemia, was shown by Moore in normal volunteers to produce a type of ileus that was severe but responded rapidly to electrolyte correction. Streeten carried out experiments on isolated segments of intestine of various animals, including man. He found that in a medium resembling the plasma in paralytic ileus, in which sodium and chloride are low, spontaneous peristalsis and response to neostigmine were

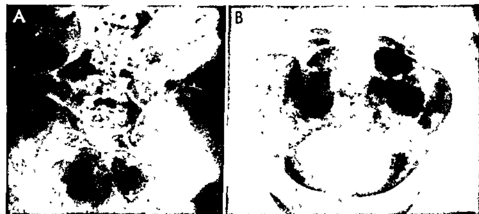


Fig. 107.—**A**, extreme distention of colon. Arrow points to area of calcification in pelvis, suggestive of ureteral calculus. **B**, intravenous pyelography confirms presence of ureteral calculus, confirming the cause of the ileus.

much impaired. Parasympathomimetic drugs, therefore, cannot be expected to function until plasma electrolytes are corrected.

The mechanical factor of distention may initiate a paralytic ileus and always perpetuates it. Under certain conditions, huge amounts of gas can accumulate in the stomach or intestine. Excessive aerophagy may cause such gas. Inhalation anesthesia applied through a mask with positive pressure may force air into the stomach as well as into the lungs; in a recent case huge distention of the stomach was produced in this fashion, inducing a particularly troublesome postoperative ileus. While paralytic ileus occasionally is initiated by such relatively massive insults, it usually is due to the accumulation of repeated small increments of swallowed gas and fluids in the presence of feeble peristalsis.

Whatever the means by which it is produced, as soon as distention occurs, the physiologic effects are the same as those of the distention produced by

acute mechanical obstruction. Actually there always is an important factor of mechanical obstruction, for the heavy filled coils angulate or perhaps are compressed by abscesses that contribute to the ileus.

Certain drugs also tend to perpetuate an ileus. Outstanding in this group is morphine. Using balloons in the upper small intestine, Rowlands, Chapman, Taylor, and Jones found that the action of morphine is characterized by (1) a striking decrease in propulsive contractions and (2) the repeated occurrence of spasm or temporary sudden elevation of tone. Thus morphine retards the transport of material along the alimentary tract. Tincture of belladonna and atropine also were found to decrease intestinal contractions.

DIAGNOSIS.—The diagnosis of paralytic ileus is usually not difficult. In the presence of one of the known causes of the disease, a nontender, silent, distended abdomen is characteristic. If vigorous treatment is not instituted, extreme meteorism develops quickly. Large amounts of fluid are regurgitated, and obstipation ensues.

It is most important to differentiate mechanical postoperative obstruction from paralytic ileus. In typical cases differentiation is easy, but in many it is extremely difficult. The abdominal X ray is helpful. On the scout plate, isolated accumulations of gas and fluid in the stomach, intestine, and colon are typical of paralytic ileus, while a ladder pattern in the small intestine, combined with a collapsed colon, is the sign of mechanical obstruction.

When an ileus believed to be paralytic has existed for several days, particularly if no improvement has occurred on adequate treatment, it should be assumed that mechanical obstruction is present. It must be re-emphasized that mechanical obstruction may be present when peristalsis is reduced in amount or absent.

TREATMENT.—The important features of therapy are gastrointestinal decompression by intubation, complete restriction of oral intake, and parenteral administration of blood, fluid, and electrolytes.

This is the situation in which the long intestinal tubes exhibit their greatest usefulness. Unfortunately, the diminution in peristalsis makes intestinal intubation particularly difficult, and all surgeons, regardless of the type of tube they have used, have found that the tube passes into the upper jejunum consistently less frequently than in the presence of mechanical obstruction with active peristalsis. The sooner intubation is done, the greater are the chances of success.

However, even if the tube fails to pass into the jejunum, gastric suction will prevent further accumulation of air and will aspirate a great deal of fluid. Though gastric suction relieves the ileus, a much longer period of treatment is required than with an intestinal tube.

Adjuvant measures include hot stupes, which serve to make the patient

more comfortable, and enemas. Theoretically, methods that reduce sympathetic overactivity should be used. Spinal anesthesia or injections of vasopressin (Pitressin) have been employed in many institutions; we have not found them to be of value. *Shackelford* recommended the use of di-isopropyl flurophosphate, an agent that blocks the sympathetic ganglia.

During the period the patient is under treatment, daily scout films will indicate progress. Diminution in size of small-bowel loops and the appearance of gas in the colon are favorable signs.

If the obstruction does not relent, or if it seems to become more acute, operation must be considered. A period of five to seven days probably should be the maximum length of time in which conservative measures should be used. Thereafter the surgeon must plan to relieve the distention by operation and expect in a high percentage of cases to find unsuspected mechanical obstruction.

There is no question but that operation has been delayed too long in many cases of postoperative or other ileus believed to be paralytic. Until recently surgery was discarded in favor of the conservative program outlined above. This course was based upon unhappy experience with blind enterostomy on the part of older surgeons. Jejunostomy usually managed to drain only a single loop of distended intestine, often killed a patient, and rarely cured him. However, the writer believes that the pendulum has swung too far and that it is important to reaffirm the positive benefits of surgery in certain cases of paralytic ileus.

The rationale for operation under such circumstances is based on the fact that distended bowel will not contract. This fact was shown by *Hotz in 1909* and has been substantiated since by many clinical observations. Therefore, unless the distention can be relieved in some fashion, the ileus will persist, and if relief cannot be obtained by simpler measures, operation is necessary.

The most dramatic type of surgery for so-called paralytic ileus is that which is associated with peritonitis and will be outlined in Chapter 26, where treatment by a radical operative procedure will be discussed. Here, though, a *second type of case in which surgery may be lifesaving must be emphasized.* In such cases as the one illustrated in Figure 108, the paralytic ileus is not associated with peritonitis, and surgery is necessary to accomplish decompression. In one less fortunate case in our hospital, severe postoperative distention followed a cystectomy. This was limited chiefly to the colon and was believed to be due to paralytic ileus. Conservative measures failed to reduce the distention, and 10 days later the cecum perforated. Autopsy showed no evidence of organic colonic obstruction, and death was ascribed to paralytic ileus.

From these and other similar experiences a few conclusions may be drawn.



Fig. 108.—Colonic ileus treated by operation. **A**, multiple loops of gas-filled small intestine. Barium enema had shown incomplete filling but no definite obstruction. **B**, barium enema two months later shows normal colon.

Man, 72, was admitted to hospital with acute massive hemorrhage from gastric ulcer. Two years before he had had severe myocardial infarct, from which he apparently had recovered. One year before he had had massive hemorrhage from gastric ulcer; this had been treated conservatively elsewhere, with recovery from hemorrhage but with persistence of ulcer pain. After entry to Massachusetts General hospital he was given transfusions, and emergency gastrectomy was carried out with anterior Hofmeister anastomosis. Postoperative course was not smooth, but he steadily improved until two weeks after operation, when he became greatly distended and had active peristalsis. Intestinal tube could not be passed through anastomosis. X ray showed dilated small bowel in ladder pattern. Barium enema (*A*) revealed gas and fluid but no obstruction in left colon. Laparotomy was carried out. Entire small intestine was found to be greatly distended. There were few partially obstructive adhesions near ileocecal valve. Cecum was not dilated; entire colon was palpated, with negative results. Small intestine was emptied by suction and adhesions cut. Forty-eight hours later, patient's abdomen became hugely dilated, even more so than before, and peristalsis was absent. As patency of gastrointestinal tract had been established as far distally as cecum, cecostomy was planned under local anesthesia. Cecum was found to be greatly distended with gas. Distention subsided immediately after cecostomy, and patient improved steadily thereafter. Normal bowel movements resumed in about 10 days. He returned to hospital in two months, when another barium enema was negative (*B*) and cecostomy stoma was closed. He remained in excellent health during two years of observation.

If decompression by gastric or intestinal tube fails, operative intervention should be carried out whenever a patient's condition is deteriorating from what appears to be a paralytic ileus. The operative procedure preferably should include deflation of the small intestine by aspiration, careful exploration to eliminate any mechanical block, and cecostomy. By these means, the intestinal tract is given every opportunity to recover as rapidly as possible from the effects of the distention.

B. COLONIC ILEUS

Colonic ileus is an unusual disease manifested by serious distention of the colon which may be severe enough to require laparotomy but for which no organic cause can be found. The onset is acute and closely mimics large-bowel obstruction due to cancer.

Colonic distention in the absence of small-bowel distention may occur for several reasons. Mechanical obstruction due to cancer, diverticulitis, or volvulus is by far the commonest cause. In the usual forms of paralytic ileus, both large and small intestine become dilated. However, in some instances of paralytic ileus the distention is seen first in the colon. This situation is most likely to appear in old age. The initiating process may be intraperitoneal, such as acute cholecystitis (Fig. 109) or a pancreatic abscess; it may be extraperitoneal, such as a renal stone, or it may be extra-abdominal, such as pulmonary embolism or a myocardial infarct, or due to plumbism (Fig. 110). Paralytic ileus that follows some known cause may be classified as secondary colonic ileus.

Primary colonic ileus, on the other hand, develops without any known cause. If symptoms are so severe that laparotomy needs to be done, no cause for the obstruction can be found or appears in the postoperative period. There are several theories of the origin of primary colonic ileus. The writer prefers to classify the condition as a variant of paralytic ileus, because it so closely resembles the secondary colonic ileus described above. Colp, however, has presented clinical evidence that this is a form of spastic ileus of the colon. The disease has excited little comment in recent literature.

DIAGNOSIS.—The diagnosis of a secondary colonic ileus usually is not difficult, because of the presence of the underlying cause. However, the differential diagnosis may be very hard and include such dissimilar lesions as diverticulitis and myocardial infarction. Primary colonic ileus, however, is so unusual an entity that it can rarely be accepted as a diagnosis without proof by laparotomy that no organic obstruction exists.

In some cases of colonic ileus the scout film shows dilatation of the colon. Barium administered by rectum runs into a dilated colon with no evidence of

obstruction and very little peristaltic activity. Unfortunately, exactly the same picture may be demonstrated with some cancers of the left colon, which can be missed entirely on the barium enema film in the presence of acute obstruction.

In some cases the barium column ascends a normal descending colon and then fails to pass the splenic flexure. This picture closely mimics an obstructing cancer of the splenic flexure. The fact that the splenic flexure usually is involved rather than a straight section of the colon leads to the speculation

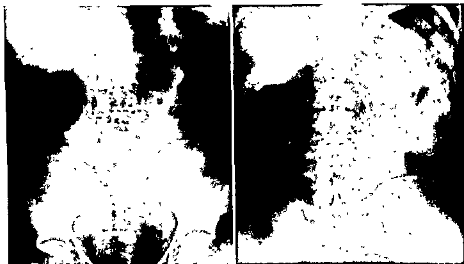


Fig. 109 (left)—Colonic ileus. Marked dilatation of colon due to acute cholecystitis.

Fig. 110 (right)—Colonic ileus due to lead poisoning. Battery maker, 24, had had abdominal pain, obstipation, and vomiting for 48 hours. X rays showed greatly distended colon. Spontaneous deflation occurred, and barium enema gave negative results.

that once distention occurs, mechanical angulation of the bowel may accentuate the ileus.

In the cases collected by Colp, the ileus appeared most commonly in patients with neurotic traits. At times the barium enema demonstrated an apparent organic narrowing of some portion of the colon which either disappeared on repeated examinations or could not be confirmed at laparotomy. The assumption, therefore, was made that the ileus was due to spasm.

TREATMENT.—The disease would excite relatively little interest were it not for the fact that operation is necessary to rule out other causes of obstruction. It is probably unnecessary to point out that when a possible diagnosis of cancer of the colon is entertained, it is safer to carry out an exploration than to accept a diagnosis of colonic ileus. Consequently, surgeons occasionally op-

erate for large-bowel obstruction and find nothing to account for the distention. The decision must then be made for or against some type of decompressive procedure. It has been found that this type of ileus occasionally is very slow to resolve spontaneously. For example, Longmire encountered an instance of what he was certain at operation was spastic ileus of the colon that required a protracted period before the distention could be controlled by intubation. It seems wisest, therefore, to perform a cecostomy at the time of the exploration (Fig. 111). Colp prefers either cecostomy or ileostomy and notes that they have often been lifesaving. Colonic function is regained with-

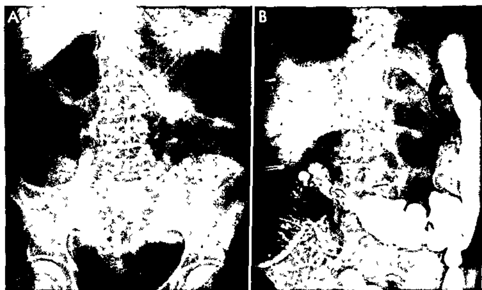


Fig. 111.—Phantom obstruction of splenic flexure. Man, 59, entered hospital because of distention and obstipation of several days' duration. Flat film (**A**) *shows marked distention of large bowel. Barium enema would not pass beyond splenic flexure, though no obstructing lesion was demonstrated. Cecostomy was performed. Subsequent barium enemas gave negative results, as shown by* **B**, *taken two months later.*

in a short interval. Careful sigmoidoscopy and the barium enema must be repeated before the tube is removed, since an intraluminal tumor may have eluded detection at laparotomy.

C. SPASTIC ILEUS

Spastic ileus is an extremely interesting type of intestinal obstruction. It may be defined as obstruction due solely to spasm, in which no other causative agent is involved. Although in many clinics it is diagnosed frequently, in the Massachusetts General Hospital it is believed to be a rare occurrence. Intestinal spasm, however, is common. Green-apple colic or the pain ac-

companying gastroenteritis is due to spasm. Spasm probably is an important contributory factor in many instances of obstruction, particularly when obturation is the cause. A ropelike, contracted colon can be palpated not infrequently in thin, neurotic patients. Every doctor's wastebasket is littered with descriptions of the spastic colon.

Fluoroscopic study of the gastrointestinal tract occasionally demonstrates areas of spasm, in either the small or the large bowel. For example, in mor-

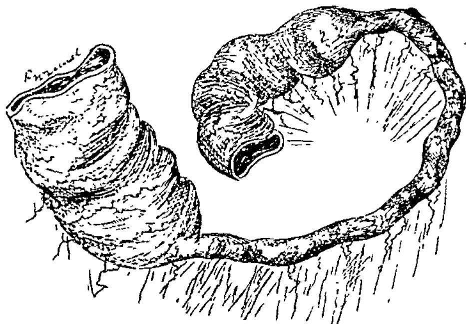


Fig. 112.—Spastic ileus. This is Dr. J. B. Murphy's famous case, in which both spasm and obstruction actually were demonstrated. Spasm occurred in patient with lead poisoning and disappeared at laparotomy on manipulation of intestine.

phinism, lead poisoning, and some deficiency states, areas of spasm appear and disappear. It is presumed that the intestinal colic which accompanies these states is due to the spasm. Occasionally, even in normal persons, such areas may be seen, and they may originate intussusception. These evanescent areas of spasm, however, are not synonymous with true spastic ileus. In the latter, spastic areas persist for a long enough period to produce an actual obstruction. Demonstration at laparotomy is extremely uncommon, not only because the disease is rare, but because relaxation of a spastic area may occur under anesthesia.

There has been a tendency to include a heterogeneous group of obstructions under this diagnosis. For example, a case of intestinal obstruction in

which operation has not been performed, but in which spontaneous improvement has occurred, may be called "spastic ileus." Also, some ill-defined observations of lesions actually comprising variants of paralytic ileus may erroneously have been included with those of spastic ileus.

Historically, the disease was first described by J. B. Murphy, in 1896. He operated because of severe obstructive symptoms of several days' duration on a patient who had been subject to lead colic. At laparotomy he withdrew a loop of small intestine, as hard and contracted as a rope, above which the bowel was dilated. Under observation, the area of spasm relaxed slowly, relieving the obstruction. The loop of intestine was returned to the abdomen, and the patient made an uneventful recovery (Fig. 112).

Thereafter many similar lesions were described, and in 1930 Zimmerman was able to collect 157 cases from the literature. However, since that time relatively little attention has been paid to the condition, a fact indicating that modern methods of correction of underlying physiologic factors have diminished the incidence.

A critical review of the literature on this subject suggests that many of the reported cases were actually instances of intestinal spasm secondary to systemic infection or to electrolyte imbalance or were instances of ileus in which no cause could be found and which were tagged as spastic ileus. The case histories are often disappointing.

In a true case of spastic ileus, there are typical pathologic findings. The gross appearance of the involved bowel has been described by Fromme as follows.

> Spastic ileus is due to a spasmodic muscular contraction of a portion of the intestinal tract. It may affect either the large or small bowel, or both, in one place usually, or possibly in many places. It generally includes a few inches of the gut only, although at times a considerable length is compromised. A common location is the lower portion of the ileum. The typical appearance is striking and unmistakable. A section of gut a few inches in length is contracted to the limit, rendering it white, bloodless and so firm that it often may be picked up by one end and held horizontally without bending. The contracted part does not merge gradually into the adjacent bowel but stops abruptly at either end, the rest of the intestine remaining normal, but, if the trouble lasts long enough, the proximal bowel dilates, as in any other form of obstruction. The spasm frequently persists after the abdomen is opened, although it may disappear, and it is sometimes found even at autopsy.

A second type of constriction was described by Zimmerman as a *ringlike* furrow, as if a string had been tied about the gut. Finally, in some cases, transient spasms moving from place to place along the bowel have been described. The spasm, in some instances, has persisted and has been demonstrated at autopsy.

Beside the idiopathic spastic ileus that is unassociated with other causes, severe enterospasm may be secondary to many other diseases. It may be local in origin, associated with irritation from foreign bodies, worms, undigested food, bleeding into the bowel, hernia, mucosal ulceration, or circulatory disturbances. It may be reflex in origin, following abdominal trauma, or associated with lesions in other viscera. It may be associated with disorders of the nervous system, such as neuresthenia or hysteria.

The diagnosis of spastic ileus can be made with certainty only at laparoto-

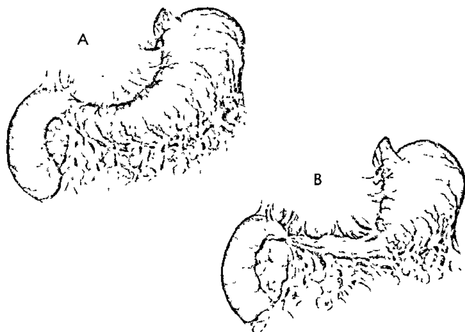


Fig. 113.—Spastic obstruction of pylorus. (See page 292.) A, stomach and duodenum as they appeared before onset of spasm. B, extreme spasm in a "trigger area" produced by manipulation of Levin tube in esophagus.

my be the demonstration of spasm and by absence of other lesions. Because of these criteria, the diagnosis has not been made for many years in the Massachusetts General Hospital. However, the disease may be suspected in the absence of laparotomy if obstructive symptoms respond readily to conservative measures, such as decompression and use of antispasmodics, particularly if the patient has neuresthenic symptoms as well.

The writer has seen only one case in which there was evidence that idiopathic spasm was severe enough to obstruct the gastrointestinal tract. The patient, a 47-year-old neurotic woman, who had previously required shock

treatments and had had many medical misadventures, including a large X ray burn for which plastic surgery was necessary, had complained for two years of attacks of epigastric pain. She would feel well and suddenly would be seized with a severe attack of subxiphoid pain and intractable vomiting. The attack would persist for several hours. The pain would not respond to antispasmodics, required meperidine (Demerol) for relief, and was associated with right upper quadrant tenderness and spasm. Between attacks physical examination was not remarkable except for the demonstration of a 15-pound weight loss. Complete studies, including several Graham tests as well as gastrointestinal series, were negative, although several years before a duodenal ulcer had been diagnosed by X ray.

Laparotomy was carried out under thiopental-ether anesthesia. Preliminary examination of all viscera showed no abnormalities. During the course of the removal of a grossly and microscopically normal gall bladder, a Levin tube, which had retracted into the esophagus, was advance by the anesthetist. Immediately a most dramatic change took place in the stomach and duodenum. The entire antrum and pylorus and the first portion of the duodenum suddenly contracted into a mass as stiff and as hard as wood and turned pale white as blood was squeezed out by spasm. This contraction persisted for about five minutes and then gradually relaxed. A few minutes later, the same change was reproduced by another manipulation of the Levin tube. This lasted for a shorter period, and during it inspection of the entire intestinal tract showed that no other areas were involved. In both instances the spasm involved exactly the same spot; there was a sharp boundary between normal and spastic areas (Fig. 113).

Since it seemed probable that the patient's symptoms arose from similar attacks of spasm in the trigger area and since they had been completely unresponsive to medical therapy, the involved segment was resected and a Billroth II anastomosis made. The resected specimen showed no pathologic changes on microscopic examination. The patient was completely relieved of her attacks of vomiting. She had, however, three years later, lost weight, still complained of bizarre abdominal pain, and showed further psychiatric symptoms.

24

Mesenteric Thrombosis and Embolism

INTERFERENCE WITH THE BLOOD SUPPLY of the intestine will lead to loss of function and consequent intestinal obstruction. The manifestations vary considerably, depending upon the nature of the occlusion.

ETIOLOGY.—Mesenteric arterial thrombosis originates from atherosclerotic plaques. Arterial embolism is less common and arises from a thrombus in the left side of the heart or from an arteriosclerotic plaque that becomes detached from the proximal aorta. Because of the large size of the superior mesenteric artery, it is much more frequently involved by an embolus than the inferior. Its anatomic location, parallel to the aorta, makes it much more susceptible to embolism than the celiac axis, which is approximately the same size.

Mesenteric venous thrombosis may arise from many causes. It usually follows infection in the viscera where venous drainage is through the portal system. Appendicitis, pelvic disease, cancer of the colon, and strangulated external hernia may lead to it. Surgical operations on any of these viscera also may initiate such a thrombosis. Splenectomy is particularly apt to incite this complication, particularly when the splenic vein is left as a long stump beyond the inferior mesenteric. In this portion, venous emboli may form and pass through the portal vein, producing infarction of the liver (Zahn's infarcts). Even the operation of hemorrhoidectomy has led to mesenteric venous thrombosis. Such thrombosis may also follow blunt trauma, as described by McCune, Keshishian, and Bender. Blood dyscrasias may produce it. In certain instances, termed agnogenic thrombosis, no antecedent cause can be discovered (Fig. 114).

The relative frequency of these lesions is quite different in various reported series. Mersheimer, Winfield, and Frankhauser found in an exhaustive survey of the literature that venous thrombosis was commoner than arterial. However, McClenahan and Fisher found that the opposite was true in their

material, as it was at the Massachusetts General Hospital during the period of this study. Uricchio, Calenda, and Freedman estimated that approximately 1,350 cases had been reported. Bowen and Felger, in a collected series of 1,142 cases, found that arteries were involved in 51.2 per cent, veins in 43.8 per cent, and both in 6 per cent. Johnson and Baggenstoss, reporting



Fig. 114.—Mesenteric thrombosis. Man, 60, complained of abdominal pain of 1 week's duration. At exploration a section of ileum about 3 feet long was found to be involved by mesenteric venous thrombosis. Recovery was uneventful after resection and anastomosis. Specimen shows site of thrombosis. No cause was discovered to account for thrombosis.

from the Mayo Clinic, found that emboli accounted for only 19 of 171 cases of mesenteric vascular occlusions.

PATHOLOGY.—In unusual cases thrombotic occlusion of the superior mesenteric artery may be followed by establishment of an adequate collateral circulation and survival. Thrombosis of the entire inferior mesenteric artery has been noted not infrequently by Linton at the time of operation for aortic aneurysm. However, as a general rule obliteration of large branches of the mesenteric arteries leads to necrosis, gangrene, and perforation of the intestine. When veins are involved, the process is much less fulminant, and several days may pass before it is clear that the patient is ill enough to require an operation.

At laparotomy, the demarcation between normal and infarcted bowel

usually is easy to determine. But the boundary may not be sharp and the surgeon must be certain that he has excised an area wide enough so that further necrosis will not occur after the operation.

SYMPTOMS AND SIGNS.—The disease may be suspected in old patients who have cardiac disease and have a dramatic onset of severe abdominal pain



FIG. 115.—Massive resection of small intestine. Man, 35, had extensive mesenteric venous thrombosis requiring resection of right colon and all intestine except for proximal 10 inches of jejunum. In this picture, functioning jejunotransverse colostomy is seen. Patient lived approximately two months, suffering from severe diarrhea and *progressive malnutrition.*

that is followed by vomiting, diarrhea, and shock. The movements may contain copious amounts of blood due to the infarction. The abdomen remains flat during the early stages but gradually becomes distended as gangrene progresses. The abdomen is tender, and peristalsis tends to be diminished or absent. Though the white cell count is variable, there is a tendency to marked leukocytosis, and white cell counts of 30,000 to 40,000 are not uncommon. The temperature remains normal until gangrene occurs. When the throm-

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At laparotomy, the demarcation between normal and infarcted bowel

PART IV: OTHER PHASES OF OBSTRUCTION

25

Postoperative Obstruction

A. GENERAL CONSIDERATIONS

SURGICAL OPERATIONS BRING IN THEIR WAKE a certain number of complications, including intestinal obstruction. Of the causes of this obstruction the most frequent and important by far are adhesions and bands, which were discussed in Chapter 19. In this section attention will be directed to the other causes. They include (1) wound dehiscence followed by ventral hernia; (2) intraperitoneal abscess; (3) obstruction of an anastomosis, either from malformation due to mechanical defects in its production, edema, or, at a late date, fibrous stricture; (4) perforation of an anastomosis; (5) obstruction of an external stoma by edema, prolapse, or late stricture; (6) hernia, either through a reconstructed pelvic floor, through a trap left behind an anastomosis, or through a mesenteric or omental defect, and (7) volvulus about an ileostomy or colostomy site. The frequency of this iatrogenic type of obstruction in the series studied in the Massachusetts General Hospital is indicated by the fact that during the period 1947-1955 there were 406 obstructions due to adhesions and 50 others secondary to operations but due to these other causes.

It is apparent that some of the miscellaneous complications listed in this section are peculiar either to the early or to the late postoperative phases, while others are encountered indiscriminately in both. Roughly, half of the obstructions were observed within the first two weeks after operation, and the other half at varying periods thereafter. However, nearly all of the deaths from this cause occurred in the early postoperative period.

bosis involves the venous system, the onset tends to be more gradual and the diagnosis much more difficult.

The diagnosis can sometimes be made by X rays, with the demonstration of a single loop of distended thickened bowel and evidence of intraperitoneal fluid. Peritoneal aspiration may yield bloody fluid, proving the presence of infarcted gut.

TREATMENT.—The accepted therapy of this disease is resection of the involved segment of bowel with end-to-end anastomosis as soon as possible. This frequently requires an extensive resection (Fig. 115). At times the entire gut is found to be gangrenous, so that the situation is hopeless.

When resection is possible, the surgeon must assure himself that there are pulsating arterioles and open veins at the site of the anastomosis. He also must be certain that no other loops of intestine are involved by an independent thrombosis.

Engelman reported on a patient who was treated early by anticoagulants, with recovery. In the Massachusetts General Hospital anticoagulants have not been given preoperatively; it has seemed unwise to use them as a primary method of treatment, since they may increase the amount of bleeding into the damaged intestine.

Embolectomy has been attempted in a number of instances for mesenteric arterial embolism. There were no survivals, however, until recently, when, in our hospital, Shaw and Rutledge removed an embolus from the main trunk of the superior mesenteric artery; the patient was living and well six months later. Since then, several successful embolectomies have been carried out.

MORTALITY.—The mortality of mesenteric thrombosis and embolism is extremely high, since many patients are moribund when they come into the hospital. Bowen and Felger in 1942 collected 116 cases in which recovery followed bowel resection. In 26, more than 200 cm. of intestine had been resected. To their number, Uricchio, Calenda, and Freedman, in 1953, added 42 cases. Wangensteen reported 43 cases with mesenteric infarction and recovery in 10. In the Massachusetts General Hospital, from 1947 to 1955, a particularly unfortunate group was encountered. There were 10 cases, and all the patients died. In only two cases was it possible to attempt a resection.

In occasional instances there is spontaneous recovery, with an old partial or complete block of one of the mesenteric vessels discovered at post-mortem examination. Rosenman and Gropper observed one patient in whom gangrene did not follow mesenteric arterial embolism, but healing led to intestinal stenosis due to acute obstruction several months later.

quently for many days, even when intubation was producing no significant improvement. The lower mortality in their series is striking.

2. TYPES OF EARLY POSTOPERATIVE OBSTRUCTION.—When early postoperative obstruction occurs, the surgeon should consider the possibility of either of two complications. *Wound dehiscence* may be manifested first by obstruction. The diagnostic discharge of serum from the wound may never occur, since only a knuckle of intestine may protrude into the incision and produce obstruction from this Richter's hernia. If profuse serous discharge is observed, the diagnosis is easy.

An *intraperitoneal or incisional abscess* often produces a high degree of obstruction. Usually the abdomen is silent, and the diagnosis of peritonitis and paralytic ileus, therefore, is made. Rapid improvement nearly always follows drainage of the abscess.

By far the commonest early postoperative obstruction is adhesive obstruction. This was noted in 72 out of the 102 cases. Obstruction following dehiscence of a pelvic floor (after combined excision of the rectum), torsion about an anastomosis, ileostomy or colostomy, ileostomy dysfunction, severe paralytic ileus, and volvulus accounted for the remainder.

3. PREVENTION.—There seems to be no question but that early postoperative obstruction is much less common that it was a decade ago. Most of this improvement may be ascribed to concomitant intubation and to more intelligent blood, fluid, and electrolyte replacement. In addition, meticulous attention to surgical detail is necessary. Careful peritonealization, especially in the pelvis, accurate hemostasis, use of relatively small ligatures, avoidance of devascularization of the omentum, attention not to pull on the intestine with gauze-covered fingers, care to prevent spillage of foreign material such as glove powder into the peritoneal cavity, closure of all intraperitoneal traps, and careful wound closure to avoid dehiscence are elementary surgical details. All frequently are overlooked.

Many surgeons do not use prophylactic gastric suction to reduce the incidence of postoperative ileus. The writer, however, believes that it is a most valuable detail and uses it regularly in all major abdominal procedures. If it is employed, a Levin tube should be inserted before anesthesia is started. The tube is kept on suction throughout the operation and for about 24 hours afterward. If there has been an active peritonitis, or any anastomoses have been made in the stomach or intestinal tract, a longer period is wise. Preferably, after operations on the stomach the tube is left in place for 48 hours, while after operations on the colon it is retained for three or four days, or until gas is passed by rectum.

4. SIGNS AND SYMPTOMS.—Even though all precautions have been taken, some patients will have intestinal obstruction a few days after operation. The

B. EARLY OBSTRUCTION

Early postoperative intestinal obstruction is ordinarily defined as that which occurs less than two weeks after an operation. The antecedent operation is nearly always intra-abdominal. However, other procedures may initiate the obstruction; for example, chest operations may lead to abdominal distention and volvulus of the cecum. Early postoperative mechanical obstruction is probably the most troublesome of all types of obstruction to diagnose and often is exceedingly difficult to treat, since the patient is already debilitated from an operation and the surgeon hates to subject him to another if there is any reasonable alternative.

1. Incidence and mortality.—The incidence of early postoperative intestinal obstruction is difficult to determine. Patients who improve rapidly after suction on an inlying gastric or intestinal tube generally are considered to have paralytic ileus, and, since a measure of paralytic ileus is expected after every abdominal operation, this complication usually is not listed in diagnostic files. On the other hand, if postoperative obstruction has led to a significant prolongation of the patient's hospital stay or to reoperation within two weeks of the original operation, the case is classified as one of early postoperative obstruction. By these criteria, 102 cases were listed in the period 1947-1955 in the Massachusetts General Hospital. This type accounts for 10 per cent of all intestinal obstructions. It occurs, in round figures, at the Massachusetts General Hospital once in every 150 abdominal operations.

Considering the fact that these figures must exclude many minor cases of postoperative obstruction, it would be expected that relief by intubation would be secured infrequently and that mortality would be comparatively high. Actually, intubation proved successful in only 15 per cent of the 102 cases. The over-all mortality was 23 per cent.

Relatively little attention has been paid to this subject in recent surgical literature. This situation clearly is due to the introduction of gastrointestinal decompression by suction drainage, since before that the complication was discussed frequently. Recent reports are difficult to evaluate, because the number of patients who have recovered after brief periods of intubation cannot be ascertained.

A paper by McCune and Keshishian apparently deals with similar material, since only 17 per cent of their patients recovered after conservative measures alone, including intestinal intubation. This treatment was abandoned for surgical intervention if there was not significant improvement within a few hours. There mortality was 8.5 per cent. Early recourse to surgery was the most important feature distinguishing their cases from those treated in the Massachusetts General Hospital, where conservative therapy was used fre-

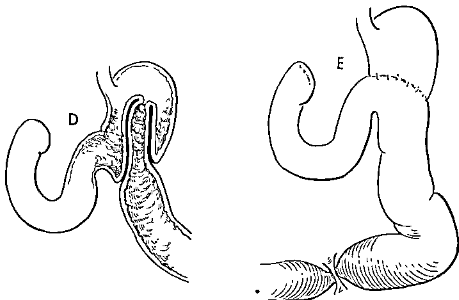


Fig. 116 (cont.) D, stomal intussusception. **E,** intestinal obstruction distal to anastomosis.



Fig. 117.—Stomal obstruction. Man, 55, had had vagotomy and posterior gastroenterostomy month before view **A,** was made. Stomal obstruction had remained complete, as shown by this picture, despite secondary operation at which adhesions were cut about efferent loop. At third operation, omentectomy, gastric resection, with posterior Hofmeister anastomosis, and double jejunostomy were carried out. Postoperative course was uneventful. **B,** taken a week after last operation, shows jejunostomy tubes in position.

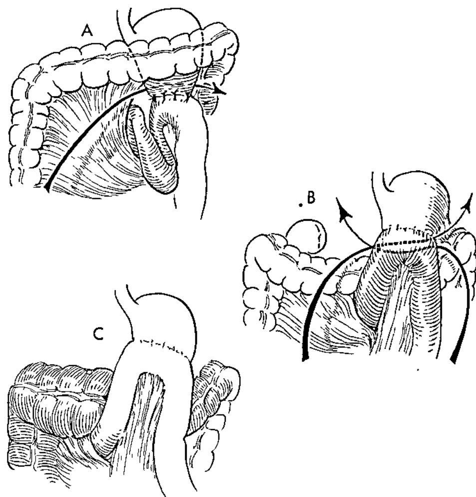


Fig. 116.—Obstruction following operations on stomach (exclusive of stomal obstruction). **A,** Peterson's hernia. Site of herniation of distal loops of jejunum is shown by arrow. **B,** hernia behind antecolic anastomosis. **C,** obstruction of right colon by antecolic anastomosis **(continued).**

symptoms tend to be insidious in onset and may consist only of distention, mild "gas pains," nausea, or obstipation. Pain usually is dulled by morphine and is hard to interpret. All the symptoms rarely occur simultaneously, and the diagnosis must be made on suspicion rather than on certainty. The X ray film may be diagnostic, though often persistent postoperative paralytic ileus makes interpretation difficult.

5. TREATMENT.—When postoperative obstruction is suspected, a long intestinal tube should be inserted and run down with as little delay as possible. If full-blown distention is awaited, passage of the tube will become impossi-

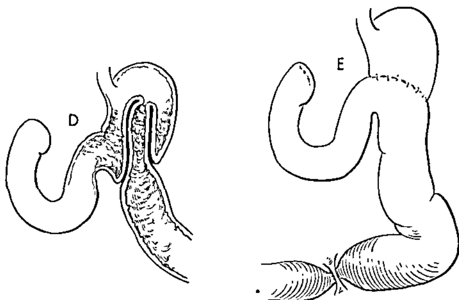


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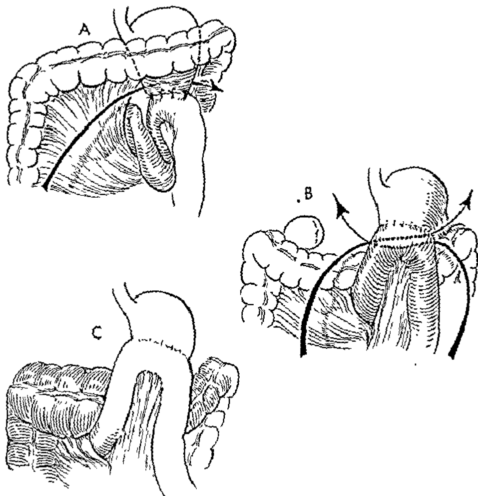


Fig. 116.—Obstruction following operations on stomach (exclusive of stomal obstruction). A, Peterson's hernia. Site of herniation of distal loops of jejunum is shown by arrow. B, hernia behind antecolic anastomosis. C, obstruction of right colon by antecolic anastomosis (*continued*).

symptoms tend to be insidious in onset and may consist only of distention, mild "gas pains," nausea, or obstipation. Pain usually is dulled by morphine and is hard to interpret. All the symptoms rarely occur simultaneously, and the diagnosis must be made on suspicion rather than on certainty. The X ray film may be diagnostic, though often persistent postoperative paralytic ileus makes interpretation difficult.

5. Treatment.—When postoperative obstruction is suspected, a long intestinal tube should be inserted and run down with as little delay as possible. If full-blown distention is awaited, passage of the tube will become impossi-

tient vomits large quantities of bile and intestinal fluid that contain no food. Later a variable amount of right upper quadrant tenderness develops, and sometimes the large loop becomes palpable. This "afferent-loop syndrome" has been described by Wells and by Warren (Fig. 118).

Many cases of stomal obstruction, particularly those due to edema, subside spontaneously on suction drainage of the stomach and omission of oral



Fig. 118.—Afferent loop syndrome. Woman, 60, for two years after gastric resection, despite secondary operation, had had serious weight loss and repeated attacks of vomiting of bile. There was tenderness over dilated afferent loop which can be seen to overlap stomach in this picture. At third operation, sharp angulation of afferent loop was corrected by secondary resection of stomach and antecolic anastomosis. She was relieved completely of her symptoms.

intake. However, because of the relatively high incidence of true mechanical obstruction, reoperation should not be delayed for over a week. At that time any abnormal findings must be corrected. Adhesions may need to be cut, or an obstructing mesocolon that has slipped down on the jejunum after a postcolic anastomosis, elevated higher on the gastric wall. If afferent and efferent loops are available, an enteroanastomosis between them will provide the easiest way out, though this procedure is not the wisest when the original diagnosis was duodenal ulcer, since shunting of the alkaline duodenal contents away from the stomach may lead to a stomal ulcer. A complete revision of the anastomosis may be necessary.

ble. Withdrawal of all oral intake is essential. Intravenous fluids, electrolytes, and blood or plasma must be given as they are indicated. Oxygen inhalation is rarely of any value. In the absence of evidence of peritonitis, enemas may help relieve a paralytic ileus. Hot packs increase the comfort of the patient.

With these simple measures, intestinal function usually resumes in a few days, and the tube can be withdrawn. Success so frequently is the rule that it is necessary to emphasize those cases in which simple suction treatment is likely to fail or is actually dangerous. They occur as follows.

1. When the onset is sudden and symptoms severe or when the abdomen is silent and tender, suggesting a strangulating obstruction. Fortunately, strangulating obstruction, with the exception of prolapse through a newly reconstructed pelvic floor, is comparatively rare in the early postoperative phase. Actual gangrene was encountered in only two of the 102 cases.
2. After combined abdominoperineal resection.
3. After ileostomy and colectomy for ulcerative colitis.

Several variations of obstruction are encountered after operations on the various viscera and will be discussed in order.

1. Operations on stomach.—Postoperative obstruction may be due to stomal obstruction, small-bowel obstruction from adhesions, hernia about the anastomosis, obstruction of the right colon, or retrograde stomal intussusception (Fig. 116).

The problem of *stomal obstruction* will be considered only briefly here. It occurs after both Billroth I and Billroth II anastomoses. The causes are numerous. Electrolyte imbalance, with an overload of sodium and depletion of potassium, and low serum protein with edema of the gastric mucosa are important contributing factors. Mechanical obstructions about the stoma are encountered less frequently. A mass of devitalized omentum may lead to obstructing adhesions of the efferent loop after an antecolic anastomosis, and a fat, heavy omentum should therefore be removed at the time of gastrectomy as a preventive. The efferent loop, also, may become adherent in the peritoneal incision and obstruct. With retrocolic anastomoses, the commonest mechanical cause of obstruction is slipping of the mesentery of the colon down over the jejunum; as it thickens with edema, the jejunum is compressed tightly (Fig. 117).

Mechanical obstruction of the afferent loop produces a different set of symptoms. If it is early and complete, back pressure will produce a dehiscence of the duodenal stump. At a later period a long antecolic afferent loop may prolapse behind the efferent, producing complete obstruction and gangrene, as recorded by West. More commonly, obstruction is incomplete, so that gradually, over a period of months or years, the afferent loop becomes greatly dilated. Characteristically, at infrequent intervals thereafter, the pa-

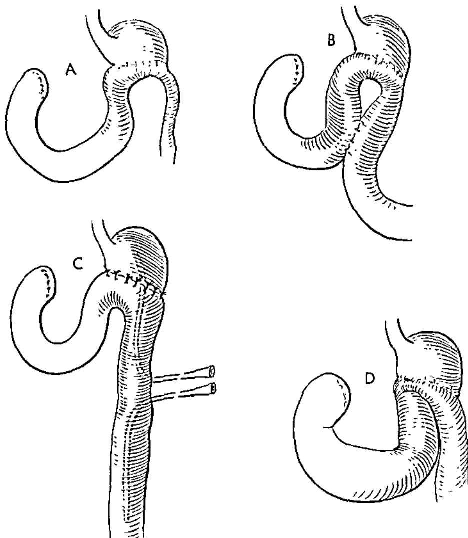


Fig. 119.—Methods of correction of stomal obstruction. **A**, efferent loop obstruction. Stoma appears grossly normal. **B**, treatment of efferent loop obstruction by entero-enterostomy. **C**, treatment of efferent loop obstruction by double jejunostomy. **D**, afferent loop obstruction.

Whenever reoperation is done for efferent-loop stomal obstruction, we believe at the Massachusetts General Hospital that it is wisest to conclude the operation with the double jejunostomy technique of Allen and Donaldson. One catheter introduced into the jejunum is led back into the stomach to be used for decompression. As an alternative method, this catheter may be inserted directly into the stomach, as done by Harris and Smith. A second is directed distally and is used for feeding. Thereafter any aspirate from the upper tube is reinserted through the lower, and, even though the stomal obstruction may persist, the patient's nutrition can be maintained. Usually, after seven to 10 days it becomes clear that liquids injected into the lower tube are running back through the stoma. At that time X rays may be taken to confirm the presence of a patent stoma, and shortly thereafter the tubes may be withdrawn (Fig. 119).

Small-bowel obstruction due to adhesions may occur in the early postoperative course and be confused with stomal obstruction. If numerous adhesions are found about an old appendix scar, at the time of laparotomy for gastric resection, trouble may be anticipated. When such obstruction occurs, the treatment follows that generally accepted for intestinal obstruction, except that passage of an intestinal tube through the anastomosis is likely to be difficult and early laparotomy is therefore wise. Partial small-bowel obstruction occurring months or years after a gastrectomy may produce symptoms typical of the dumping syndrome, and relief follows lysis of these adhesions.

Hernias about the anastomosis nearly always follow antecolic anastomoses, the distal jejunum prolapsing behind the afferent and efferent loops from right to left in front of the colon. Other varieties are less common; jejunal loops may prolapse from left to right behind the anastomosis, or a long afferent loop may pass from right to left. Hernia likewise can follow postcolic anastomosis (Peterson's hernia), but this type is virtually unknown at the present time because a long afferent loop is no longer used and the tiny hiatus behind a short afferent loop is nearly inaccessible to the wandering jejunum. Stammers collected 15 cases of hernia about an anastomosis.

Such hernias should be considered when the patient in his early postoperative phase complains of undue epigastric pain or tenderness and has signs of stomal obstruction. This is a strangulating obstruction and death can occur very soon unless laparotomy is carried out.

The prophylactic closure of all potential loops about gastrojejunal anastomoses has been advocated by Stammers and by Cannon and Weeks. This is, at best, a difficult task and may lead to an angulation that in itself will obstruct the anastomosis.

Right colon obstruction can follow an antecolic gastrojejunostomy when

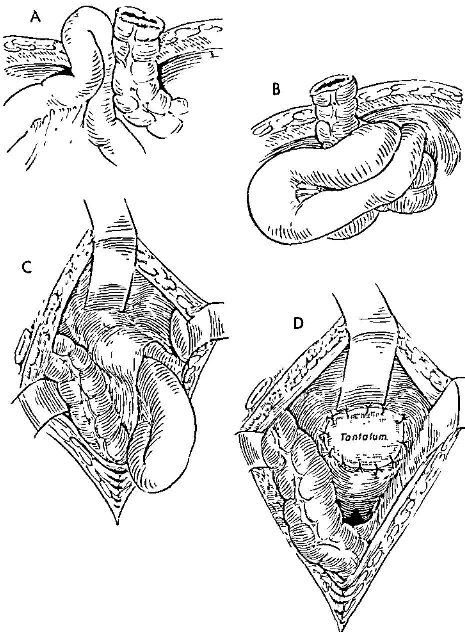


Fig. 120.—Postoperative obstruction following combined abdominoperineal excision of rectum. **A,** partial wound dehiscence, with small intestine escaping adjacent to colostomy. **B,** prolapse of loop of ileum through left gutter, lateral to colostomy stoma. Loop must be withdrawn and trap closed. **C,** prolapse of loop of ileum through peritoneal floor. **D,** reconstruction of peritoneal floor by tantalum mesh.

the afferent loop of jejunum is too short. This type of obstruction usually is observed in the early postoperative phase, four to seven days after gastrectomy. An X ray will demonstrate gas distending the right colon to the vicinity of the anastomosis. A cecostomy by the modified Gibson tube technique should be carried out, since once edema subsides, function of the colon will resume.

Retrograde intussusception through a gastrojejunostomy stoma is an uncommon complication but may produce a variety of symptoms, including pain, nausea, vomiting, and bleeding, because of the varying degrees of obstruction and infarction that are produced. The diagnosis can be made by the observation of an intragastric mass after barium administration. Often this mass shows typical circular parallel striae.

The commonest type is a retrograde intussusception of the efferent loop into the stomach; it accounts for approximately 80 per cent of all jejunogastric intussusceptions, according to Irons and Lipin, who collected 100 cases. Intussusception of the afferent loop into the stomach is the next commonest type. In the third and final type, both loops undergo intussusception.

This complication may occur any time from a few hours to many years after operation. Reoperation is necessary as soon as possible, since the mortality rises rapidly with delay. According to Vink, within 48 hours of onset the mortality rate is 10 per cent, and after 48 hours, it is 50 per cent. The anastomosis should be redone, or a gastroenterostomy converted to a gastric resection, for simpler measures are likely to lead to recurrence.

2. OPERATIONS ON RECTUM.—A serious group of obstructions follows combined abdominoperineal resection of the rectum. Several mechanisms are involved. In addition to obstruction due to adhesions in the operative field and obstruction due to partial wound dehiscence about the colostomy stoma, prolapse of a loop of small intestine lateral to the colostomy stoma or through a rent in the pelvic floor are complications peculiar to this operation. The list of causes indicates not only that obstruction is common but also that much of it is due to serious anatomic abnormalities that cannot be relieved by suction therapy. Consequently, surgery usually is necessary for relief. Protracted trials of suction therapy may introduce serious complications, such as perforation of a loop of prolapsed intestine in the pelvis. Unless intubation and suction give complete relief within a few days, reoperation should not be delayed in the hope that intubation over a longer period will succeed (Fig. 120).

Ulfelder and Quinby found that small-bowel obstruction developed in 8 per cent of 249 patients who had a Miles' resection of the rectum between 1940 and 1949 in the Massachusetts General Hospital. Of the 15 deaths after this operation, small-bowel obstruction accounted for seven. The obstruction

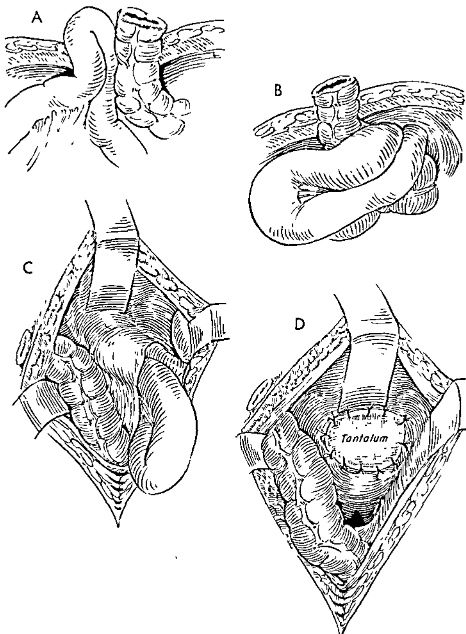


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usually developed on the sixth or seventh postoperative day. Of the 20 obstructions, five were due to prolapse through the pelvic floor, two to prolapse down the left gutter, and the others presumably to adhesions. While intubation led to relief in 10 of the cases, death in the remainder was due to persistent attempts to secure relief by this method so that the patient was moribund at the time operation was carried out. These authors strongly recommended early surgery when relief of all symptoms was not obtained promptly on intubation.

Unfortunately, this recommendation of early surgery for postoperative obstruction has not always been followed, and combined abdominoperineal resection continues to be accompanied by high mortality from obstruction. In the 1947-1955 series there were 24 cases of postoperative obstruction (or about five per cent of all instances of combined resection). Fifteen patients had adhesions, seven had a loop strangulated through the pelvic floor, one had prolapse about the colostomy stoma, and one had wound dehiscence. Eleven of these patients died. Prolapse of a loop through the pelvic floor carried a particularly high mortality.

Goligher, Lloyd-Davies, and Robertson encountered mechanical small-bowel obstruction in 2.8 per cent of 1,302 patients who had combined resections. The diagnosis was confirmed at operation or at autopsy in all 37 cases. Adhesions accounted for 15 cases, obstruction from pelvic floor defects for 12, and obstruction in the vicinity of the colostomy for 10. In only three cases was there a hernia lateral to the colostomy stoma, due, they believe, to the use of an iliac colostomy and closure of the lateral gutter.

Careful closure of the peritoneal floor is the key to prevention of most of these catastrophes. Adequate lateral mobilization of the pelvic peritoneum, closure of the defect by a continuous suture reinforced by numerous interrupted sutures, avoidance of postoperative distention, and delay of ambulation for eight days after operation are important details.

The lateral trap about the colostomy stoma should be closed meticulously to prevent prolapse through the lateral gutter. It must be admitted that many surgeons do not close the trap lateral to a colostomy stoma, particularly when the opening is a wide one. They argue that a wide opening is safe and that many sutures of this trap fail to hold. There are some instances in which a short colon cannot be used for a midline stoma and be sutured to the lateral side of a wide abdomen. However, at the Massachusetts General Hospital we agree with Goligher that the trap should be closed as carefully as possible and that closure is easier if a lateral colostomy stoma is used.

3. Ileostomy.—Operations for ulcerative colitis also carry a high incidence of postoperative obstruction, whether ileostomy is done alone or in conjunction with subtotal or total colectomy. Many of the problems are the

same as those encountered with cancer of the rectum, though to a different degree. Adhesions are most important, particularly after colectomy because of the wide area of dissection. Pelvic floor defects are less serious because less pelvic peritoneum need be sacrificed and a firm closure is always possible.

Other technical details of importance include as complete peritonealization of the gutters as possible; as careful closure of the lesser omental bursa



Fig. 121.—Strangulating obstruction due to volvulus about ileostomy stoma. Ileostomy, without closure of gutter, had been performed several months before. Patient now complained of severe abdominal pain, vomiting, and absence of ileostomy output of 12 hours' duration. Abdomen was silent and tender throughout. On this film, few mildly dilated loops of intestine are visible. At operation, carried out immediately, intestine was found to be cyanotic and greatly distended but viable. Recovery and cure followed closure of gutter. In this instance, radiologist was loath to make diagnosis of obstruction.

as can be done, to prevent retrograde herniation through the foramen of Winslow, and complete obliteration of the gutter lateral to the ileostomy opening (Fig. 121).

An important cause of early postoperative obstruction after the operation of ileostomy is ascribable to the stoma itself. "Ileostomy dysfunction" may be due to a variety of causes. If the ileum simply is drawn out of the peritoneal

cavity, an encircling rim of granulation tissue shortly appears just proximal to the mucosal margin. As this granulation tissue contracts, obstruction is produced. Another cause of dysfunction is tight compression of the ileum in the abdominal wall.

To reduce the incidence of dysfunction, several technical details are of importance. To minimize compression in the abdominal wall, a circular excision of a button of skin and fascia is carried out when the ileostomy is performed as described by Dennis. The constricting rim of granulation tissue may be eliminated by suturing ileal mucosa to skin by the technique of Brooke or Crile and Turnbull. By the application of these methods, ileostomy dysfunction has become much less common, though it has not been eliminated.

Dysfunction is characterized by intestinal cramps and by an increased volume of ileostomy discharge. The ileum may actually squirt its contents through the narrow aperture, and discharge may be so profuse that electrolyte depletion occurs rapidly.

The methods available for control are described in detail by Warren and McKittrick, who found some measure of dysfunction in 62 per cent of their cases in which the techniques of Brooke and Turnbull were not used. They include gentle dilation of the stoma, catheterization of the stoma, division of the constricting collar of granulation tissue, and, as a final resort, complete operative revision of the stoma.

The unusual frequency of intestinal obstruction after operations for ulcerative colitis is shown by the figures of Wheelock and Warren. They found 26 admissions for obstruction for 18 patients of 232 who had had operations for ulcerative colitis. All but one of the obstructions occurred within a year of the original operation. Four of these 18 patients died of obstruction, but three of them had no surgery for it. Two of these three had previously survived obstruction treated by intubation, which presumably led to the hope that similar treatment would again be successful. This report emphasizes the danger of treating late mechanical obstruction by the long tube.

4. Appendectomy.—Obstruction after appendectomy is not uncommon, particularly when the appendix has perforated before operation. Drains in apposition with the small intestine contribute to obstruction. Since sepsis is a causative factor and there is no serious mechanical abnormality, the situation is particularly favorable for conservative therapy, with drainage of abscesses as they become manifest. Complete obstruction should be relieved relatively soon, or a vigorous operative attack may be necessary (*see* Chapter 26). It must not be forgotten that a Witzel ileostomy has saved many from death from obstruction due to early postappendectomy obstruction.

5. Hysterectomy.—Obstruction following pelvic operations such as hysterectomy usually is due to local adhesion of the intestine to the vaginal stump or peritoneal floor. Meticulous peritonealization at the time of the original operation is necessary to prevent it.

6. Resection and Anastomosis.—Obstruction following resection and anastomosis of the bowel may be due to defects in the anastomosis itself. In the early postoperative period it may be due to edema about the anastomosis or to anastomotic leaks. Later, stenosis of the anastomosis may occur. Edema about the anastomosis is the commonest cause; it can be diminished by meticulous attention to technical details. Many years ago, placing a decompressive enterostomy tube just above a suture line in the small intestine was a favorite maneuver to aid in the prevention of this type of obstruction. Now this is rarely necessary, since careful technique and postoperative decompression by suction through a gastric or intestinal tube are more effective. Benson advises enterostomy after resection of congenital strictures or atresias in infants. When edema occludes an anastomosis in the colon, however, a tube cecostomy is a most effective maneuver.

Leakage from an anastomosis is always serious and frequently fatal. If it is recognized early, exteriorization of the anastomosis, when feasible, is the best procedure. Too often general peritonitis occurs and exploration is not carried out until the patient is moribund. Occasionally the leak is small and results only in an abdominal fistula, and the patient survives.

Prolapse of intestinal loops behind an anastomosis, as behind a side-to-side ileocolostomy, can produce a serious obstruction. Very similar is prolapse of an intestinal loop through a mesenteric trap, where the mesenteries of the anastomosed sections of bowel have not been sutured accurately. These obstructions cannot all be prevented, for there are many traps that cannot be closed completely. Whenever it is possible to do so, and whenever the trap is a small one, this technical detail is important.

C. LATE POSTOPERATIVE OBSTRUCTION

Of the few lesions that are found only in the late postoperative period, stenosis of an anastomosis, ileostomy or colostomy, is the only type of obstruction that has not been discussed elsewhere.

Late stricture of an anastomosis is uncommon, but appears to be abetted by several factors. They include creation of an anastomosis in inflamed bowel, placing of an anastomosis below the pelvic floor, use of two layers of continuous chromic catgut sutures, production of a large diaphragm at the anastomosis, or a prolonged period of defunctioning of the anastomosed bowel (Fig. 122).

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26

Intestinal Obstruction and Peritonitis

ONE OF THE MOST DIFFICULT types of intestinal obstruction to treat is that which is associated with peritonitis. This combination of diseases is not infrequent. Intraperitoneal abscesses were associated with or initiated 17.8 per cent of all adhesive obstructions studied by Perry, Smith, and Yonehiro. The therapeutic management of intestinal obstruction of peritonitis when either exists alone has become reasonably well standardized. However, when they are encountered in combination, the problem is much more difficult. The mortality of intestinal obstruction accompanied by intraperitoneal obstruction is much higher than that for simple obstruction; the figures of Perry *et al.* indicate that abscesses elevate the mortality from 3.8 per cent for simple adhesive obstruction to 7.3 per cent. Measures usually effective for the one disease may be considered to be contraindicated by the presence of the other. Thus, lysis of obstructing adhesions is known to be the best therapy for the intestinal obstruction they have produced, but the operation customarily is considered to be very dangerous in the presence of peritonitis. It is the writer's belief that this therapeutic dilemma can be resolved only by drastic treatment of the obstruction, which, if it fails to respond rapidly to decompression by intubation, will require radical surgery in spite of the concomitant peritonitis.

Any vigorous attempt to return the intestine to normal in the presence of peritonitis generally has been considered to be useless, since the intestine is supposed to be suffering from paralytic ileus that would persist even if the obstruction were relieved. Yet there is every indication that this belief is unjustified. Thus, peristalsis can often be heard or actually observed even in the presence of a general peritonitis. In the cases under discussion, peristalsis has recovered after a remedial operation as effectively as after the usual laparotomy, though a little less rapidly.

If a patient should die very soon from acute general peritonitis, the mani-

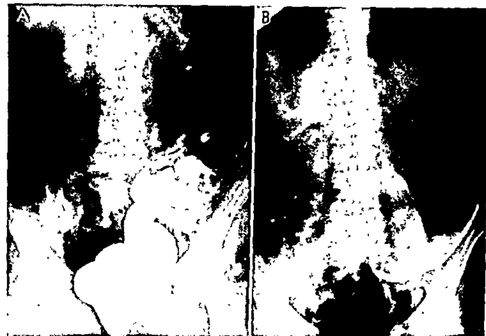


Fig. 122.—Late anastomotic stricture. Woman, 62, had three-stage resection for diverticulitis. Since she was extremely ill, colostomy was not closed until four months after resection. Three years later she returned with narrow anastomotic stricture illustrated here. Despite obstruction, she had so few symptoms that she thought she *did not need operation. Resected specimen showed stricture at line of anastomosis.* Lumen of colon was only 3 mm. in diameter. A, small amount of barium has been forced past stricture into dilated sigmoid. B, after evacuation some barium is retained above stricture, while rectum is empty.

Interesting experimental data bearing upon anastomotic stricture has been provided by Enquist and Levowitz who carried out resection and anastomosis of the colon in dogs. A closed, aseptic technique was used in 21 dogs that had had a previous colostomy; lumina of limited size resulted in 12, while 6 of them had complete water-tight septa. In 12 anastomoses performed by the open method in previously defunctionalized colons, no limitation in the lumen resulted. Finally, when the colon was functioning, no limitation in the lumen resulted from either method of anastomosis.

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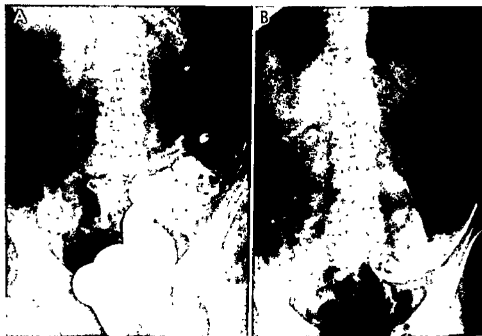


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tomycin. Fluid balance is followed most accurately by the use of an inlying catheter, so that the urinary output is known accurately. Normal electrolyte levels are maintained by the proper administration of sodium and potassium chloride, as determined by frequent chemical analyses of the serum. Blood transfusions are given regularly to secure a normal blood volume and hemat-

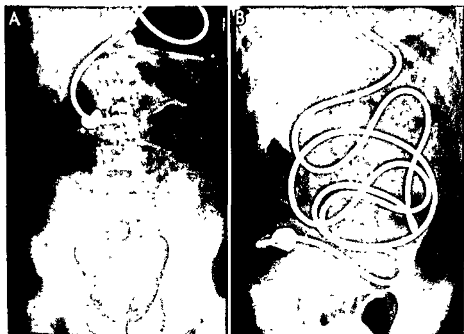


Fig. 123.—Successful treatment of postoperative ileus by intestinal tube. Two weeks before entry, boy, 14, had had appendectomy with drainage. Eight days later he had nausea, vomiting, cramps, and signs of spreading peritonitis. A, abdominal film on entry. Temperature was 103 F., pulse rate 100, and white cell count 30,000. Abdomen was distended, without peristalsis. Pus was draining from incision. B, final film, taken eight days later. Tube has progressed to ileocecal valve, distention has been relieved. Gas is visible in stomach, small intestine is near normal, and there is a good deal of gas in colon. Tube was withdrawn shortly afterward and patient discharged six days later. This method of treatment, usually successful, fails in cases discussed in this section.

ocrit level. If the serum protein remains low, plasma or human albumin is given. An attempt is made immediately to pass a long intestinal tube well down into the intestine if it is not already there; the longer this procedure is delayed, the less is the chance of success (Fig. 123).

If the patient is going to recover on this regimen, definite evidence of improvement should be obtained within a few days. If the evidence is not clear, the surgeon must not stay his hand too long. He must recognize the fact that

festations of intestinal obstruction would not have had time to appear; this fulminating type of peritonitis, therefore, need not be considered further in this discussion of obstruction. However, if the peritonitis enters a less acute phase, plastic adhesions or intraperitoneal abscesses may obstruct the bowel. In a slightly more chronic phase, abscesses disappear but the plastic adhesions solidify, so that obstruction becomes more severe. In a series of 17 patients treated by the author who had not responded to conservative therapy, acute peritonitis with intraperitoneal abscesses was found in 14, a chronic granulomatous peritonitis with multiple small abscesses in one, acute plastic peritonitis without abscesses in one, and chronic granulomatous peritonitis without abscess in one.

The causes of death from intestinal obstruction reduced to fundamental physiologic terms include, (in the absence of gangrene), blood, fluid, and electrolyte deficits, the effects of mechanical distention, and inanition. While the first two of these can be relieved by replacement therapy and intestinal deflation, a functioning gastrointestinal tract is essential to prevent death from starvation. Meanwhile, when the obstruction is relieved, normal nutrition allows a resolution of the peritonitis. Therefore, early recognition and alleviation of intestinal obstruction is an essential factor in the treatment of peritonitis.

Intestinal obstruction in the presence of peritonitis is due either to adhesive obstruction or to compression of the bowel by one or more abscesses. In many instances, drainage of one or more abscesses relieves the obstruction. In others, relief of the distention by intubation permits early resumption of normal intestinal activities. In severe cases, as in those discussed in this chapter, the tube may reduce distention but fails to relieve the obstruction. In these instances, it is the contention of the writer that the surgeon should proceed with a bold operation designed to relieve the cause of the obstruction.

Three essential features should be present before the patient is subjected to one of the operations described below. The patient must have peritonitis, he must have intestinal obstruction, and he must give the clinical impression that he is a *desperately ill person in whom conservative measures have been* unsuccessful and in whom persistence in these measures will result in death.

It is obvious that the surgeon must consider many details in the therapy of these very ill patients. Most important is his timing of any surgical re-exploration. As this problem now usually arises in patients in an early postoperative phase, the surgeon must appraise every patient who is not doing well as a *possible candidate for further operative therapy.* If indications of either peritonitis or obstruction appear, vigorous treatment must be started. Antibiotic therapy is stressed, usually with a combination of penicillin and strep-

However, if it has not passed the ligament of Treitz, aspirating needles or small trochars may be used. Occasionally so much solid debris is present that it must be actually milked out of the bowel through an enterotomy incision. This emptying of the small bowel on the operating table is an absolute necessity, for if the loops of fluid-filled intestines are left in place, the mechanical effects of distention are not relieved and subsequent reobstruction is likely.

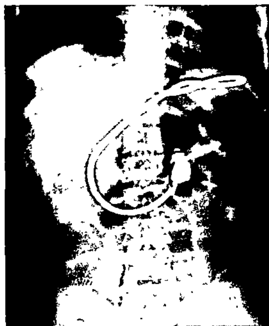


Fig. 124.—Intestinal obstruction and peritonitis. Boy, 16, had been in hospital for 10 days with general peritonitis originating from ruptured appendix. He had had obstruction for week. Intestinal tube would not progress beyond site shown in film and was draining 3,000 cc. daily. Abdomen was distended, tender, and without peristalsis. No discrete masses or abscess could be identified. Operative findings are shown in Figure 125.

When the lumen of the small intestine has been compromised severely, *restoration of intestinal continuity by resection and primary anastomosis* is necessary to avoid re-obstruction.

Intraperitoneal anastomosis in the presence of an acute infection must carry an increased hazard, though this is difficult to evaluate. Theoretically it should be greater when the intestine is resected than when a gastrectomy is done for a perforated ulcer, because of the greater infectivity of the intestinal contents. In the series under consideration, four resections and anastomoses of the small intestine and four enteroanastomoses without resection were carried out. Of this total of eight patients undergoing intraperitoneal

such a patient will not be able to use his intestinal tract for at least five days after a secondary operation because of trauma from the procedure. The patient must have enough vitality to carry him over this decisive period. A failure of the supply of veins for intravenous administration or throat pain due to the intestinal tube will make the operation more urgent. The important detail is to keep the patient continuously supported as well as possible and not to wait too long before the secondary operation is done.

A. OPERATIVE PROCEDURE

The operative procedure is carried out under a general anesthesia induced preferably by pentothal combined with a muscle relaxant. If possible, the intestinal tube has been passed beyond the ligament of Treitz, and any fistulae are intubated with catheters to aid in the identification of intestinal loops. A generous incision is necessary, which usually means that the previous operative incision will have to be reopened, since necrosis of the intervening skin flap may occur if two incisions are placed too near together.

The objectives of the operation may be summarized as follows:

1. Relief of the obstruction. This is the essential feature of the operation and must be accomplished if the patient is to survive. By some means a functioning gastrointestinal tract must be formed, which empties through a normal or artificial anus.

2. Retention of as much intestinal absorptive area as possible. High short circuits, such as jejunocolostomies, should be avoided whenever there is a reasonable alternative.

3. Excision or closure of the source of continuing peritoneal contamination when possible. Thus, appendectomy may be necessary. A perforated diverticulum of the sigmoid may be resected, exteriorized, or sutured.

4. Removal of as many collections of pus, blood, or necrotic tissue from the peritoneum as possible.

5. Relief of abdominal distention by the evacuation of the contents of the small intestine.

There are a number of methods by which these objectives can be achieved. They may be classified in several groups.

Re-establishment of intestinal continuity by lysis of adhesions is the procedure to be employed whenever the condition of the patient permits. It involves the meticulous freeing of all adhesions from the ligament of Treitz to the ileocecal valve. Abscesses are evacuated as they are encountered. The distended small bowel must be aspirated as this is done (Figs. 124, 125).

Removal of fluid and gas from the distended intestine can be accomplished most easily by manipulating the long intestinal tube downward.

However, if it has not passed the ligament of Treitz, aspirating needles or small trochars may be used. Occasionally so much solid debris is present that it must be actually milked out of the bowel through an enterotomy incision. This emptying of the small bowel on the operating table is an absolute necessity, for if the loops of fluid-filled intestines are left in place, the mechanical effects of distention are not relieved and subsequent reobstruction is likely.



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anastomosis, six did well, one died soon after operation, and in one a fistula *re-formed because obstructing diverticulitis was not recognized or relieved.* Resection and anastomosis of the obstructed colon in the presence of peritonitis undoubtedly causes a higher mortality because of the poorer blood supply of this portion of the gut. A perforated cancer of the cecum is best treated by resection and end-to-end anastomosis, as shown by Patterson. On the other hand, if resection is carried out for a perforated obstructed lesion of

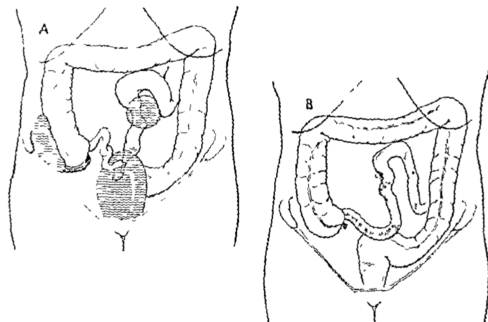


Fig. 125.—Intestinal obstruction and peritonitis. Operative findings in case illustrated in Figure 124. A, distal ileum was found to be obstructed by plastic adhesions and multiple intraperitoneal abscesses (shown in cross-hatched areas). B, at conclusion of operation, abscess had been evacuated, adhesions cut, obstruction relieved, and appendectomy done. Recovery was uneventful.

the *left colon, an obstructive resection with delayed anastomosis appears* less hazardous.

A third procedure is *restoration of intestinal continuity by enterocolostomy.* At times sufficient bowel is present above a lower-abdominal abscess to allow a clean enterocolostomy in a free peritoneal cavity. This is a method described by Raeder in 1918 and Sampson-Handley in 1924 and used by them with success. It was possible in only one case in this series (Figs. 126, 127).

In some instances a general peritonitis is found. Complete mobilization of the intestine may be impossible. The dissection should be started at the lig-

ament of Treitz and carried down as far as feasible. An ileocolostomy will serve as a permanent measure. Sometimes only a jejunocolostomy can be performed; this is a lifesaving procedure and it must be accepted that a secondary revision will be necessary at a later date to return more of the intestine to service.

Formation of artificial anus is a satisfactory procedure if the obstruction



Fig. 126.—Intestinal obstruction and peritonitis. Woman, 35, had had resection of terminal ileum for regional enteritis two weeks before. Lower-abdominal peritonitis had developed. Staphylococcus aureus pus was draining through incision. Large pelvic abscess was palpable. There had been complete obstruction since operation, and patient was desperately ill with severe electrolyte depletion. Film shows dilated loops of intestine. Intestinal tube had not passed ligament of Treitz.

is purely colonic, although of course it must be accompanied or followed by removal of the cause of the obstruction. When the obstruction is in the terminal ileum, a complete ileostomy may be preferable to an intraperitoneal anastomosis in the presence of widespread infection.

By these techniques, this operation of "refunctionalization of the intestine" was carried out in 17 cases and resulted in recovery in 14. It may be concluded, therefore, that for patients who have both intestinal obstruction and peritonitis, surgical measures are indicated when conservative measures fail.

The surgeon who attempts these operations must realize that he will be undertaking most difficult operative procedures. The patient must have a liberal supply of blood and fluids; the operation must be expeditious as well as thorough. However, the rewards are great, for every successful procedure represents a life saved.

In the patients discussed above, the symptoms of obstruction predominated. There are also patients in whom the features of obstruction and of

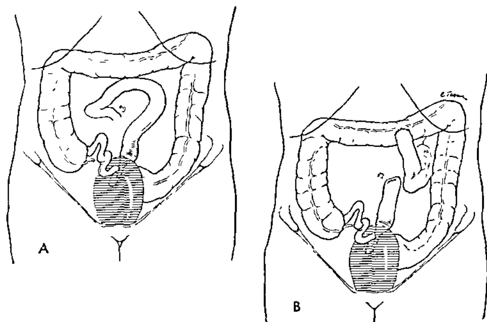


Fig. 127.—Intestinal obstruction and peritonitis. Operative findings in case illustrated in Figure 126. Ileum was found to be dilated and completely obstructed by large pelvic abscess. Intestine was divided above this area and end-to-side ileocolostomy done. Patient recovered rapidly, though it was a year before palpable evidence of abscess disappeared.

peritonitis are combined but those of peritonitis predominate. The condition of many such patients has been allowed to deteriorate to a fatal termination when an extensive operation might have been lifesaving.

Such a situation is encountered not infrequently with acute ulcerative colitis in which multiple perforations of the colon occur. The older operation of simple ileostomy for this complication was followed by a high mortality. Subtotal colectomy has been shown to be a much wiser procedure and much safer. Ripstein observed that of 11 patients treated by primary resection of the perforated colon none died, while of five treated by ileostomy and local drainage, three died.

B. PERITONEAL IRRIGATION

Whenever an extensive peritonitis is found, the question of peritoneal irrigation arises. When such irrigation was done with saline solution, as advocated by many surgeons from the time of J. B. Murphy, no clear-cut evidence in favor of the procedure was obtained. After waxing and waning in favor, the procedure generally was discarded in the belief that more harm than good resulted. However, now that antibiotics are available, it seems logical to consider their use.

Poth has been deeply interested in irrigation with antibiotics. He has, in the presence of widespread contamination, irrigated the peritoneal cavity with a large amount of 1 per cent neomycin. Sterilization of the peritoneal cavity was noted routinely within 30 minutes.

Schatten has employed intraperitoneal antibiotic administration in the treatment of acute bacterial peritonitis. In a clinical report, he described the use of oxytetracycline in 20 and neomycin in 18 patients who had acute diffuse peritonitis demonstrated at the time of operation. Four patients died, but one was moribund at the time of operation and in the others no peritonitis was demonstrated at autopsy. Neomycin was considered the drug of choice, since it caused less discomfort than oxytetracycline. The drug was instilled into the peritoneal cavity at the time of operation and postoperatively through polyethylene catheters for 72 hours at the rate of 0.5 Gm. every six hours.

The intraperitoneal administration of neomycin has certain dangers. Poth noted respiratory arrest, and Pridgen reported four clinical cases in which this occurred. Two patients recovered, but the other two died despite long-continued supportive measures. According to Webber, six respiratory arrests have now been reported after the intraperitoneal use of neomycin.

While it is certain that some substance less toxic than neomycin will be discovered in time, this still will not resolve the more funamental problem of parenteral versus topical application of antibiotics and chemotherapeutic agents. Meleney has been an advocate of the local application of these substances, emphasizing their antibacterial qualities. Lyons, however, believes that they are effective only when they are absorbed into the blood stream and that parenteral administration is the proper way to secure an adequate blood level. The argument has not been resolved.

27

Recurrent Intestinal Obstruction

RECURRENT INTESTINAL OBSTRUCTION may be due to any of several causes, but carcinomatosis, adhesions, volvulus, and intussusception are the commonest. Repeated episodes of adhesive obstruction are by far the most important from the point of view both of frequency and of difficulty in selection of the proper operative procedure.

A. INTUSSUSCEPTION

In the idiopathic type of intussusception recurrence is rare. It was found in only 2 per cent of Gross's series and usually could be cured by a plastic procedure about the ileocecal valve. Intussusception due to a tumor or to a Meckel's diverticulum is sure to recur until the initiating cause is removed.

B. VOLVULUS

Recurrent obstruction due to sigmoid volvulus is common. Bruusgaard observed two or more episodes of volvulus in 31 out of 91 patients admitted to his hospital. This indicates that about one person out of three may be expected to have recurrence. In our experience at the Massachusetts General Hospital, volvulus tends to recur until the offending loop is resected. For this reason, we have followed a clinical rule of thumb stating that one attack of volvulus in a good-risk patient is an indication for resection and that two attacks are sufficient indication in others unless unusual circumstances make it unwise.

C. BANDS AND ADHESIONS

Recurrent attacks of adhesive obstruction may be divided into two groups. In the first, attacks are acute and intermittent. In the second, there is

a chronic type of obstruction with production of daily symptoms. The latter group will be discussed in Chapter 28 and recurrent acute adhesive obstruction considered here. In both groups, the problem of drug addiction must be considered carefully. Morphine and its derivatives will produce intestinal spasm and cramps. Consequently, drugs taken for the relief of the pain of obstruction may aggravate the patient's symptoms.

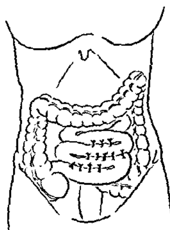
The frequency of recurrent acute adhesive obstruction is difficult to estimate accurately. Of our 401 patients with obstruction due to adhesions, more than one episode of obstruction was treated in an eight-year period in 21, or 5.2 per cent. Seven of these patients had minor attacks, relieved rapidly by conservative measures. Ten required a second operation, while three had three and one had four operations. Secondary operation for obstruction was necessary, therefore, in 3.5 per cent of the total. If these patients are followed until death, the incidence of recurrence, of course, rises.

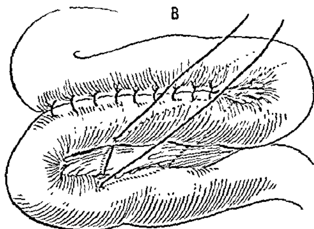
Wangensteen noted that of 352 patients with adhesive obstruction, obstruction occurred twice in the 10-year period of study in 21 patients, three times in four patients, four times in one patient, and five times in another. Recurrent attacks, therefore, were observed in 7.7 per cent of the total group.

These data indicate that recurrent obstruction due to adhesions after an adequate definitive operation is not a common occurrence. It seems apparent that the operations performed for adhesive obstruction are, in general, satisfactory and that there is no need to invoke new methods of treatment for the ordinary case of adhesions. It also is a clinical impression that recurrent obstruction now is encountered much less frequently than it was years ago. The prompt treatment of appendicitis, the decrease in incidence of peritonitis, the avoidance of talcum powder, and attention to the details of technique outlined above are some of the many factors that have contributed to this result.

When operation is carried out for recurrent intestinal obstruction, the surgeon's choice is limited essentially to three direct procedures—enterolysis, resection and anastomosis, and intestinal plication—and to one indirect procedure—sympathectomy.

Enterolysis is an effective operation provided that a normal lumen of intestine can be established in this fashion. Usually the diameter of the intestine can be restored to a normal size by lysis of adhesions. However, if a stenotic, fibrosed area is left, which continues to obstruct the intestine, the operation will be a failure and resection of this area necessary. In several instances of recurrent obstruction at the Massachusetts General Hospital in which symptoms had persisted after a previous operation, it was found that obstructing adhesions had been missed entirely at the first operation. For this reason the writer believes that meticulous lysis of adhesions from the





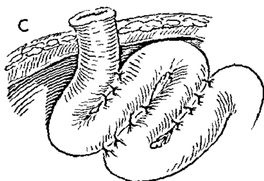


Fig. 128.—Noble plication. **A**, plication of ileum. **B**, details of method are discussed in text. **C**, plication of distal ileum has been suggested by Garlock as means to cure prolapse of ileostomy.

ligament of Treitz to the ileocecal valve is essential in any operation for obstruction from this cause; though the adhesions may not appear important at the time of laparotomy, they may be the site of a later obstruction (Fig. 129).

Resection of a portion of the intestine which cannot be freed of its obstructing adhesions is a satisfactory procedure. Not infrequently all of the small intestine will be found to be free of adhesions with the exception of a matted mass in the lower ileum. The surgeon must estimate the percentage of the total length of intestine that will require resection. The resection of 5 or 6 feet is tolerated well when the intestine is of normal length. When half or more of the intestine would need scarifice, the surgeon should attempt to use some other method, to prevent a deficiency syndrome from lack of absorptive surface.

Intestinal plication has received a great deal of attention recently as an alternative to resection. It was introduced by Noble in 1937, but despite his enthusiasm for the procedure, little excitement followed for many years. Recently, it has become popular. This operation has been advised not only for the relief of recurrent obstruction, but as a means to prevent obstruction.

Experimental plications were carried out in dogs by Weckesser, Lindsay, and Cebul. In a series of seven dogs they found that all survived the plication and gained weight. Although there was no evidence of obstruction, the average transit time through the small intestine was elevated from 88 minutes before plication to 138 minutes afterward. No complete obstruction was noted at autopsy, and the bowel maintained the pattern established at the time of plication. On the other hand, Martin, in his experimental animals, found that plication led to obstruction in several instances. Experimental evidence thus indicates that the plication introduces some danger of obstruction, either partial or complete.

A summary of the reported cases of intestinal plication was made by Weckesser and co-authors in 1951. They personally reported 10 cases, with good results in six, fair in two, and poor in two. The rules of technique they believe to be important include the following. (See also Fig. 128).

1. Completely free all adherent loops of bowel.
2. Suture adjacent loops along mesenteric borders.
3. Begin and end sutures 3 cm. from each end to keep turns gentle.
4. Make loops of proper length to fit freely across the peritoneal cavity (average 6 to 8 inches).
5. Suture bowel securely, using moderately heavy chromic absorbable gut sutures.
6. Close folds of mesentery to prevent free loops of bowel from entering if entire small bowel is not plicated.
7. Make adequate plication to cover all raw surface areas.
8. Stimulate the bowel after operation.



Fig. 129.—Recurrent intestinal obstruction. Negro woman had been operated on for ruptured appendix 15 years earlier. Thereafter she had had frequent hospital admissions because of persistent right-sided abdominal pain and vomiting. Operations included lysis of adhesions 14 years before present admission, oophorectomy 14 years before, lysis of adhesions 12 years before, cholecystectomy 11 years before, hysterectomy 11 years before, and lysis of adhesions nine years before. After these operations she had had repeated attacks of obstruction, and finally complete plication of small intestine was carried out. This was followed by attacks of obstruction, which were treated by intestinal tubes. Patient now had severe steady abdominal pain and occasional vomiting. Abdomen showed multiple scars and marked tenderness and spasm throughout right side. Flat abdominal X ray, A, reveals scattered, insignificant amounts of gas in small intestine. Barium administered by mouth discloses no evidence of obstruction (B). Because of persisting pains, exploration was carried out. Whole small intestine was freed meticulously. Multiple areas of obstruction were found. Patient convalesced gradually. Three years later she was still having mild obstructive attacks at long intervals but was working steadily and was better than she had been at any time for 15-year period prior to last operation.

Gordon Smith reported on 15 patients who had total Noble plications; two had attacks of obstruction later. In addition, 13 had partial plications, of whom three had later attacks of obstruction. He believes that the mortality attendant upon the use of plication contraindicates it except when there is such extensive peritoneal damage that recurrent obstruction seems likely to develop. In this situation he believes it is far better than enterolysis.

Seabrook and Wilson treated 34 patients by the Noble plication technique, with five failures. Boyden did 23 such operations, with one death possibly attributable to the surgery and one recurrence. Poth, Lewis, and Wolma re-



Fig. 130.—Thoracolumbar sympathectomy for intestinal obstruction Woman, 25, patient of Dr. M. K. Bartlett, entered hospital with attack of intestinal obstruction several years after appendectomy. During ensuing 13 years she had 15 other hospital admissions, nearly always for episodes of intestinal obstruction, characterized by distention, cramps, and vomiting. Several times she had lysis of adhesions, and at final laparotomy intestine was found to be entirely free of adhesions. Her attacks, however, continued. She was believed to have intestinal dyskinesia. Differential spinal block, performed during one of her episodes, resulted in prompt deflation, abdomen decreasing from 29.5 to 25.5 inches in a few hours. Bilateral thoracolumbar splanchnicectomy was done. Extent of nerve resection is shown in postoperative plate above, where Dural clips indicate resected nerves. On right, dorsal 6 to lumbar 1 were resected, and on left dorsal 6 to lumbar 2, plus greater splanchnic nerves. Patient was immediately relieved of complaints and had no symptoms of obstruction in following 10 years.

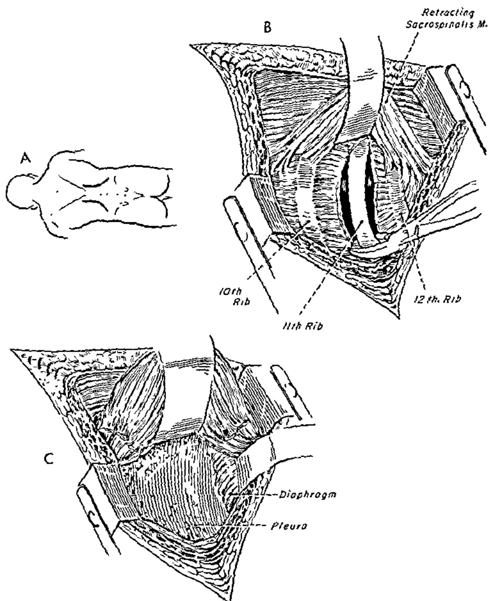


Fig. 131.—Operative procedure, thoracolumbar sympathectomy. **A**, incisions. **B**, subperiosteal resection, 11th rib. **C**, *exposure of pleura after rib resection* ***(continued)***.

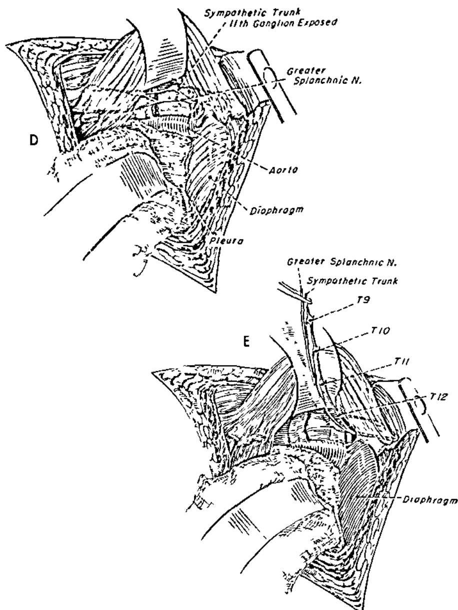


Fig. 131 (cont.).—D, pleura carefully freed from paravertebral area and diaphragm, revealing splanchnic nerve and sympathetic chain. **E,** resection of sympathetic trunk (T9 to T12 inclusive) and corresponding section of the greater splanchnic nerve.

ported 47 plications that averaged 4 feet in length, with no deaths and no recurrent obstruction.

In summary it may be said that the Noble plication procedure entails certain hazards and a definite risk of late postoperative obstruction. For this reason the writer believes that it should not be employed prophylactically or in any case in which enterolysis or resection and anastomosis can be carried out leaving only small areas of deperitonealization. When extensive raw surfaces are left after enterolysis, plication is a logical procedure. It also should be used when possible in preference to very extensive resection.

One interesting use of the plication procedure has been made by Garlock and Kirschner. After an ileostomy for ulcerative colitis, they plicate the distal 2 feet of ileum in the belief that prolapse will be prevented. They have reported its use in 32 cases with only one instance of ileostomy dysfunction.

There is still one method that can be employed for relief of the few patients who have not been helped by other measures. This is the indirect method of therapy by splanchnicectomy, which has been used with some success in a limited series of cases by Smithwick and others. Experimental evidence upon which this procedure is based was obtained by Bentley and Smithwick, who investigated intestinal sensitivity to distention by balloons after thoracolumbar sympathectomy for hypertension. Normally such a distention produces discomfort. After sympathectomy this no longer can be felt in the jejunum, though it persists in the colon (Fig. 130).

Consequently it would be expected that some patients who have pain arising from the small intestine, either from partial obstruction, from spasm, or from disordered peristaltic activity, would obtain relief from splanchnicectomy. To test the value of a sympathectomy, preliminary selective subarachnoid or paravertebral splanchnic block is indicated. If pain is relieved or intestinal deflation occurs in the presence of abdominal distention, good results are possible from the sympathectomy. However, caution should be observed in the interpretation of the results, since the patient must be having pain or distention at the time of the diagnostic block. Furthermore, some highly suggestible patients who apparently responded well to a block have not had good long-term results after sympathectomy.

The recommended operative procedure is the bilateral operation developed by Peet. Both splanchnic nerves and the lower sympathetic chain from the ninth through the twelfth dorsal are resected through the beds of the eleventh rib by the extrapleural route (Fig. 131).

Five patients have been treated in this fashion in the Massachusetts General Hospital. The most recent reports of their progress, by White and Sweet, indicate that the results in general were good. Dr. M. K. Bartlett obtained complete and lasting relief by this procedure in a patient who had had

15 previous operations for intestinal obstruction. In the writer's experience, however, convalescence has been protracted, often requiring psychiatric help, and there has been a tendency toward late recurrence of symptoms. Sympathectomy cannot be regarded as a panacea for all complicated problems of recurrent small-bowel obstruction.

Pain arising from the colon cannot be influenced by a thoracolumbar sympathectomy. The visceral efferent pathway is via the sacral nerves and hypogastric plexus. In addition, the flexures of the colon, where they are fixed to the parietal wall, are probably innervated by the intercostal nerves as well. Consequently, if distention involves the colon, thoracolumbar sympathectomy should not be considered as a method of relief.

28

Chronic Intestinal Obstruction

IN CONTRAST TO THE ACUTE obstructions described above, is the syndrome of chronic obstruction. This disease is observed in ill-defined groups of cases which have incited little discussion. However, it is becoming increasingly apparent that many patients with bizarre digestive symptoms are suffering from a form of chronic interference with intestinal motility upon which more acute attacks may be superimposed. Recognition of this syndrome often is difficult and the surgical cure even more of a problem. However, surgery furnishes the only certain method of relief.

It is apparent that nearly all lesions which produce an acute obstruction can also result in a more chronic disease in which the same type of symptoms appear though they develop in a more leisurely manner. By the same token, symptoms are less dramatic and the diagnosis of chronic obstruction much more difficult to make.

SYMPTOMS.—The symptoms may include abdominal cramps, back pain, low pelvic pain, abdominal tenderness, nausea, vomiting, and constipation or diarrhea. The outstanding feature in most cases is that one or two of the symptoms tend to predominate. The combination of cramps, vomiting, and obstipation that almost regularly accompanies an acute obstruction is not often present.

The *cramps* vary in location; while they are typically epigastric with small-intestinal obstruction or subumbilical with colonic, in this type of disease the pain is likely to be located in the section of abdomen that is actually involved. This is particularly true when there is fixation of the intestine or omentum to the overlying parietal peritoneum. Pain may be felt in the lumbar area from a pull on the intestinal mesentery. Pain in the perineum suggests diverticulitis, which may be associated with chronic obstruction.

When the intestines are fixed to the parietal peritoneum by multiple adhesions, local tenderness to palpation occurs when the bowel is obstructed. This

is in sharp distinction to the ordinary case of nonstrangulating intestinal obstruction, in which tenderness is absent. Consequently many patients with a chronic obstruction are believed to have inflammatory disease in some other viscus. The female pelvic organs or the gall bladder may be suspected as a source of pain rather than the adhesions.

Nausea and vomiting may be important symptoms. If present, they sug-



Fig. 132.—*Chronic intestinal obstruction due to adherent omentum.* Woman, 43, entered hospital complaining of abdominal pain, worse in left lower quadrant, of year's duration. She had had appendectomy many years before. Total hysterectomy was done, small area of endometriosis having been found. Extensive adhesions of sigmoid were noted. Pain was unrelieved and gradually became worse, culminating in hospital admission 18 months later. At that time she complained of diffuse abdominal pain and tenderness. Peristalsis was normal She was slightly constipated and had no nausea. X rays after barium enema, done in May and October of 1953, showed identical patterns. A, after complete filling. There is a slight conical deformity of cecum. B, postevacuation film—cecal deformity persists. Relief followed omentectomy and lysis of adhesions.

gest small-intestinal involvement. *Constipation or diarrhea,* however, does not indicate that the colon necessarily is involved but may reflect abnormalities of the small intestine. Thus, the colon is normal in regional enteritis, but partial obstruction of the ileum from this cause leads to severe diarrhea. In some instances, partial obstruction of the terminal ileum may lead to constipation, possibly because of increased fluid absorption in the small intestine. Small-intestinal obstruction from partially obstructing adhesions may occur after a gastrectomy and produce symptoms similar to those of the dumping syndrome.

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PHYSICAL SIGNS.—The physical signs, also, usually are not well marked, except in the occasional acute exacerbation, when they may be apparent. *Abdominal distention* may be present or absent; indeed, in some instances the abdomen actually may be scaphoid. *Abdominal tenderness* is not uncommon when adhesions are numerous and dense, involving the parietal peritoneum. *Peristalsis* may be normal in pitch and frequency; it sometimes is diminished in frequency and somewhat increased in amount, but is not definitely abnormal except in the presence of acute episodes of obstruction.

Laboratory investigation is apt to be disappointing. Stools should always be investigated for occult blood. The X ray examination often gives entirely normal results. Even in patients who have a small intestine almost completely obstructed from multiple dense adhesions, the abdominal film may show only small, widely separated areas of gas in the intestine. Use of the barium enema usually gives negative results but may show a dilated, almost atonic colon with few visible haustrations. Barium administered by mouth may progress to the cecum in 45 minutes despite the presence of multiple peri-intestinal adhesions. Occasionally the intestine shows scattered areas of dilatation suggestive of a deficiency syndrome such as sprue.

DIFFERENTIAL DIAGNOSIS.—By far the commonest disease confused with chronic obstruction is psychoneurosis. This is not surprising considering the paucity of objective signs that accompany either of them. Unfortunately, many of these patients show psychiatric stigmata and every unsuccessful operation strengthens the belief that they are psychoneurotic; actually the true source of their complaints may never have been discovered despite numerous operations. Soon the psychiatrist describes the patient as a victim of "polysurgery." No dicta can be set down that clearly will differentiate these two serious diseases. In general, it may be said that organic pathology is suggested when the patient has complaints similar to those described above, and refers all of them to the abdomen, particularly if they follow any operative procedure. Burning or boring pain, on the contrary, must be regarded with suspicion, and carcinophobia must be considered as a frequent cause of symptoms.

In addition, other diseases must be ruled out. Intraspinal disease, as radic-

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psychiatric care. Patient was almost unmanageable, complaining of pain but showing no objective signs indicative of organic disease. Finally, in desperation, exploration was done. Extensive adhesions involved whole distal small intestine. Lysis of dense adhesions was carried out, intestine being freed from ileocecal valve to ligament of Treitz. There were no sites of complete obstruction. Postoperatively, patient did well and was relieved of all symptoms. He promptly gained weight and four years later was still symptomless.

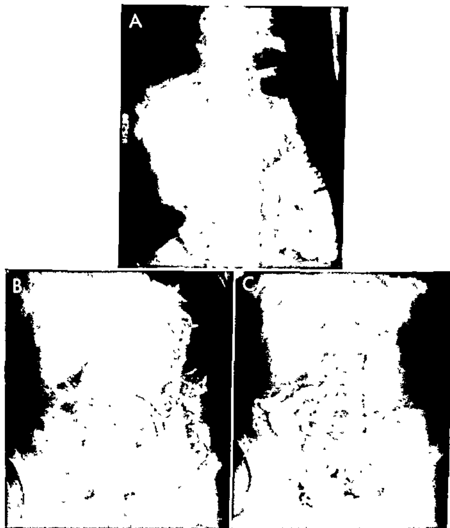


Fig. 133.—Chronic intestinal obstruction mimicking dumping syndrome. Man, 28, entered Massachusetts General Hospital because of massive upper gastrointestinal bleeding. He had had gastric resection for duodenal ulcer two years before and appendectomy seven years before. Resection for bleeding anastomotic ulcer was carried out; it was noted that he had many adhesions in right lower quadrant. Recovery was uneventful, but he was readmitted to hospital about two weeks later and discharged with diagnosis of postgastrectomy syndrome. He was readmitted shortly thereafter with definite intestinal obstruction. At this time, band obstructing jejunum was cut. He did fairly well but was readmitted three months later with what was believed to be dumping syndrome. At this time he was complaining of severe abdominal pain. He often vomited small amounts after eating. He had regular bowel movements and occasionally some diarrhea. Abdomen was scaphoid, without tenderness and with normal peristalsis. Blood counts were normal. Barium given by mouth passed to cecum in six and one-half hours. **A**, motor meal showing upper jejunum. **B**, mid-jejunum. **C**, ileum. Note the absence of any dilatation or any abnormal intestinal pattern. Medical consultant advised

29

Mortality of Intestinal Obstruction

A. ANATOMIC CAUSES OF DEATH

THE PHYSIOLOGIC CAUSES OF death were discussed in Chapter 5; the anatomic causes as demonstrated by autopsy are not necessarily the same. Though less fundamental, they include several lesions that potentially could be corrected. Table 11 is a summary of the causes of death determined by autopsy in the 1947-1955 Massachusetts General Hospital series of cases. Noteworthy among the group are unrelieved intestinal obstruction; peritonitis; pulmonary complications, of which pulmonary embolism is the most important, and pseudomembranous enterocolitis.

1. UNRELIEVED INTESTINAL OBSTRUCTION.—This has been due most commonly to carcinomatosis or compression by irremovable tumors. Mesenteric thrombosis and strangulation obstruction have led to death because the patient either was moribund on arrival at the hospital or succumbed after laparotomy showed a hopeless situation. With these exceptions, the only important group of patients who might have been saved was the small number who died because of surgical errors; *e.g.*, several patients died after combined abdominoperineal resection of the rectum because of prolapse of a loop of small intestine through the pelvic floor.

2. PERITONITIS.—Peritonitis has arisen most commonly from a perforation of cancer of the colon or from diverticulitis. Occasionally it has followed perforation of the cecum proximal to a completely obstructing cancer distal to it. Perforation of the small intestine at the site of a constrictive band, pancreatitis, tuberculosis, and ulcerative colitis may contribute to a preexisting peritonitis. Seven patients died of peritonitis and secondary obstruction following a breakdown of an intraperitoneal anastomosis. Tension on the anastomosis or lack of blood supply appeared to be much more important factors than an anastomosis in the presence of an active peritonitis. In

ulitis, tumors, arthritis, or tabes, and renal disease may be confusing. Lead colic may produce severe attacks of pain closely simulating obstruction. Somewhat similar pain has been described with porphyria.

TREATMENT.—In many cases symptoms are mild enough so that medical therapy will suffice. A low-residue diet combined with small doses of a demulcent, such as psyllium hydrophyllic mucilloid (Metamucil), or of mineral oil should be given. Antispasmodics supplemented by phenobarbital are helpful.

When symptoms become severe, however, surgical therapy must be considered. It should be emphasized that this will be performed on only a small percentage of the patients with the symptoms listed above. When surgery is elected, the treatment preferably is that of the underlying disease. This means that in most cases a direct attack should be made upon the lesion itself. In certain instances the proper procedure will be obvious; for example, an open trap lateral to an ileostomy stoma may be closed with the full expectation that recurrent attacks of obstruction from prolapse of a loop around it will be prevented. In others, a tumor that has produced repeated attacks of intussusception may be found.

The most difficult problems occur when there are extensive adhesions involving the entire intestinal tract. Here the writer's preference has been for a meticulous lysis of all adhesions from the ligament of Treitz to the ileocecal valve, with resection of any areas that appear too narrow or damaged to function satisfactorily. Omentectomy, also, is usually carried out, since the omentum forms dense adhesions that fix the intestine. In some instances the colon must be mobilized. Splanchnicectomy occasionally may be of benefit. Some surgeons, in the presence of many adhesions, prefer a plication of the intestine according to Noble's technique. Two typical cases are illustrated in Figures 132 and 133.

administration of anticoagulants. A pulmonary infarct without any evidence of thrombophlebitis is treated either by this combined method or by anticoagulants alone.

The relative infrequency of other pulmonary complications is striking, particularly since so many old-age patients were included. The very low incidence of aspiration pneumonia and of bronchopneumonia suggests that



Fig. 134.—Pseudomembranous enterocolitis.

the routine and protracted gastric or intestinal suction that is carried out in such patients essentially prevents these complications (Fig. 134).

4. Pseudomembranous enterocolitis.—A relatively rare but extremely lethal complication of intestinal obstruction is pseudomembranous enterocolitis. It accounted for seven deaths in this series.

The manifestations of the disease are variable. Usually extensive mucosal ulcerations of the colon or intestine develop proximal to an obstructing lesion. A fulminant syndrome of fever, shock, and watery diarrhea appears, followed all too frequently by collapse and death. While no one organism is encountered in all cases, the staphylococcus is by far the commonest.

TABLE 11.—SUMMARY OF CAUSES OF DEATH, ACUTE INTESTINAL OBSTRUCTION, MASSACHUSETTS GENERAL HOSPITAL, 1947-1955*

Unrelieved Intestinal Obstruction		
No. of Cases	81	40.5%
Unspecified; patient moribund; no operation		9
Strangulation		7
Surgical artefact		5½
Cancer of colon		2½
Compression by tumor or carcinomatosis		44½
Paralytic ileus		1
Death on operating table		2
Mesenteric thrombosis		9
Fecal impaction		½
Peritonitis		
No. of Cases	46	23%
Perforation of colon		14
Perforation of cecum		7
Perforation of small intestine		5
Anastomotic error		7
Cause undetermined		9½
Pancreatitis		1½
Tuberculosis		1
Ulcerative colitis with perforation		1
Pseudomembranous enterocolitis		
No. of Cases	7	3.5%
Pulmonary disease		
No. of Cases	32	16%
Embolism		16½
Bronchopneumonia		8½
Aspiration pneumonia		3
Atelectasis		½
Acute pulmonary edema		1
Empyema		1½
Mucous plug in larynx		1
Cardiovascular disease		
No. of Cases	17½	9%
Coronary		8½
Cerebrovascular accident		2½
Atelectasis		2½
Rupture aneurysm		1
Arteriosclerosis		½
Cardiac failure		1
Endocarditis		½
Arterial embolism		1
Renal Disease		
No. of Cases	4½	2.5%
Uremia		1½
Thrombosis, renal veins		1
Pyelonephritis		1
Nephrosclerosis		1
Extraintestinal		
No. of Cases	5	2.5%
Other		
No. of Cases	3½	2%
Postoperative shock		1
Portal cirrhosis		½
Hepatic abscess		½
Septicemia		½
Gangrenous cholecystitis		1
No cause of death found		
No. of Cases	2	1%

* In many instances there were 2 major causes of death, and each is listed as accounting for half a death.

a few cases in which autopsy was not done, the cause of the peritonitis was not determined.

3. PULMONARY LESIONS.—Of these, by far the most important is massive pulmonary embolism. This is a particularly frequent complication after operation for acute obstruction and accounted for 8 per cent of all the deaths. Obviously, greater vigilance is necessary to detect the complication, since in most of the cases in this series death occurred suddenly and no treatment could be administered. When any evidence of thrombophlebitis is noted, a bilateral femoral vein interruption should be done, followed by

B. FACTORS THAT INFLUENCE MORTALITY

The mortality of any series of cases of intestinal obstruction depends on several factors that are independent of the methods of treatment. The most important are the following.

1. CAUSE OF OBSTRUCTION.—For example, any series that includes a high percentage of neonatal obstruction, of cancer, or of mesenteric thrombosis will carry a high mortality rate. It is of interest that nearly half of the deaths in the series studied in the Massachusetts General Hospital were due to incurable cancer.

2. AGE OF PATIENT.—The age of the patient is an extremely important prognostic factor. The mortality in relation to age at the Massachusetts General Hospital is shown in Figure 135. In this graph the relatively high mortality of obstruction in the neonatal period does not appear because the number of cases was small. In the twenties and thirties, mortality is lowest. Thereafter it ascends gradually with age. It is of interest that in our hospital approximately a third of the patients with intestinal obstruction appear before the age of 50 and a third are 68 or older. The average age of the patient with obstruction is 61 years.

There is evidence that the relatively stationary mortality of obstruction is due chiefly to the increasing number of old-age patients who are appearing for treatment, thereby counterbalancing any improvement in therapy. For example, in 1940, McKittrick and Sarris found that the mortality at the Massachusetts General Hospital for patients 70 years of age or over was 75 per cent. At the present time the mortality in this group is 37.7 per cent, but many more patients are appearing at this advanced age.

3. DURATION OF OBSTRUCTION PRIOR TO OPERATION.—This has been an important feature. McKittrick and Sarris, in 1940, were unable to find any patient in the Massachusetts General Hospital records who had been subjected to operation within 24 hours of the onset of acute mechanical obstruction of the small intestine, excepting that due to carcinomatosis, who died after operation. This record still stands. Data referring to the duration of obstruction and mortality is summarized in Tables 12 and 13. In Table 12, deaths appearing in patients treated within 24 hours of onset were due to mesenteric thrombosis or carcinomatosis.

In the Michael Reese Hospital, Chicago, Drugas and Schiff found that operations within 24 hours carried no mortality; those within 25 to 48 hours, 5.5 per cent; those within 49 to 72 hours, 15.4 per cent; those within 73 to 96 hours, 20 per cent, and those after 96 hours, 5.7 per cent.

Delay is reflected in an increased incidence of distention, gangrene, and peritonitis. Each of these features influences the prognosis.

The disease was noted before the use of antibiotics. Travers, in 1812, described ulcers of the intestine proximal to an obstruction that were certainly suggestive of the lesion that is noted today. However, since the wide use of antibiotics in preparation of the colon for surgery, the lesion has become so much commoner as to suggest that sterilization of the intestinal tract by the broad spectrum antibiotics may lead to an overgrowth of pathologic staphylococci. This point of view is not accepted by all but is supported by such data as those of Pettet, Judd, and Dearing. They found that pseudomembranous enterocolitis was not uncommon after preparation of the colon with broad spectrum antibiotics but did not occur in a comparable series of patients after neomycin preparation. Of 71 patients prepared with neomycin-oxytetracycline, enterocolitis developed after colon resection or colostomy in eight, with death in four. Among 72 patients prepared with neomycin, no enterocolitis developed. At the present time, at the Massachusetts General Hospital we use either neomycin or phthalylsulfathiazole (Sulfathaladine) for preparation of the colon if obstruction is not severe enough to prevent such therapy. Because of the dangers of enterocolitis, the intestine is cultured routinely at the time an anastomosis is made. If Staphylococcus aureus is discovered the surgeon is alerted to vigorous treatment if postoperative diarrhea should occur. If cultures are not available, diarrhea must be regarded as a danger signal and administration of some antibiotic such as erythromycin or cathomycin begun immediately. These antibiotics are now the most effective drugs, though it is possible that they will become less effective as they are used more frequently. Supportive measures will require large amounts of intravenous fluids and electrolytes to replace the loss by diarrhea, blood transfusion, and administration of cortisone and levarterenol (Levophed). Prompt and vigorous treatment will rescue many patients.

Numerous reports of this disease have appeared in the literature. Spear summarized nine cases seen at the Massachusetts General Hospital. Numerous reports from the Mayo Clinic have emphasized the frequency of the disease. Pettet, Baggenstoss, Dearing, and Judd collected 94 cases in 28 years; in 41 cases operation was done because of cancer of the colon, and in 26 there was some degree of obstruction. All patients had had pseudomembranous lesions proximal to the site of the operative procedure. These authors concluded that the normal balance of intestinal flora may be upset in some cases by intestinal obstruction, in other cases by therapy, and in other cases by factors as yet not determined.

5. Other causes.—Other causes of death are either cardiovascular or renal in origin; extra-abdominal tumors, in which intestinal obstruction provides the terminal episode, or a miscellaneous group of infrequent diseases.

4. ABDOMINAL DISTENTION.—Wangensteen found that severe distention was followed by a mortality of 10.9 per cent, while moderate or slight distention was associated with a mortality of 3.9 per cent. In his figures, deaths "unrelated to obstruction" and untreated patients were excluded.

5. GANGRENE.—In Wangensteen's series, in the presence of marked distention, simple obstruction carried a mortality of 9.2 per cent, and gangrene of 38.9 per cent. With slight or moderate distention, the mortality rates

TABLE 12.—MORTALITY IN RELATION TO DELAY IN TREATMENT, MASSACHUSETTS GENERAL HOSPITAL SERIES*

	TOTAL CASES	DEATHS	MORTALITY, %
Less than 24 hours	208	10	4.8
24-48 hours	120	26	21.6
48-72 hours	80	19	23.8
3 days-1 week	204	47	23.0
Over 1 week	232	45	19.3

* Early postoperative obstruction was not included, since exact date of onset of obstruction was not clear in many cases.

TABLE 13.—MORTALITY IN RELATION TO DELAY IN TREATMENT MASSACHUSETTS GENERAL HOSPITAL SERIES, ADHESIVE OBSTRUCTION ONLY*

	TOTAL CASES	DEATHS	MORTALITY, %
Less than 24 hours	140	0	0
24 to 48 hours	66	7	10.6
2 to 3 days	26	2	7.7
3 to 4 days	17	0	0
4 to 5 days	25	1	4
5 to 6 days	5	1	20
6 to 7 days	10	2	20
Over 1 week	51	4	7.8

* Early postoperative obstruction was excluded, as in Table 12, since exact date of onset of obstruction was not clear in many cases.

were, respectively, 2.7 per cent and 18.0 per cent. Becker found the mortality of simple obstruction due to adhesions to be 6.7 per cent and that of strangulation obstruction to be 30.6 per cent.

6. PERITONITIS.—The presence of peritonitis greatly increases the mortality of intestinal obstruction. Perry *et al.* found that an intraperitoneal abscess nearly doubled the mortality of acute adhesive obstruction. General peritonitis, until recently, was supposed to be uniformly fatal. Peritonitis accounted for 23 per cent of the deaths from obstruction in the 1947-1955 Massachusetts General Hospital series.

C. COMPARISON OF MORTALITY RATES

A statistical study of the mortality of intestinal obstruction introduces many variables, so that published series of cases are difficult to compare.

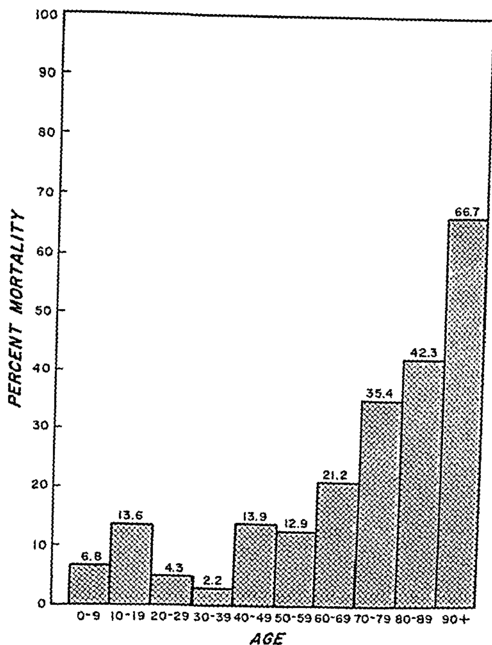


Fig. 135.—Intestinal obstruction mortality relative to age in decades.

TABLE 14.—A. MORTALITY OF MECHANICAL OBSTRUCTION, MASSACHUSETTS GENERAL HOSPITAL, 1947-1955

CAUSE	TOTAL PATIENTS	DEATHS	MORTALITY, %
Adhesions	406	28	6.9
Early postoperative	(72)	(11)	(15.3)
Other	(334)	(17)	(5.1)
Tumors	336	95	28.3
Cancer of colon	(215)	(46)	(21.4)
Carcinomatosis	(105)	(36)	(35)
Small-bowel tumor	(3)	(0)	(0)
Compression from without	(13)	(13)	(100)
Hernia			
Extra-abdominal	56	15	27
Intra-abdominal	6	0	0
Surgical sequelae (other than adhesions)	50	12	24
Diverticulitis of colon	45	9	20
Intussusception	22	3	13.6
Volvulus (primary)	18	5	28
Regional enteritis	17	1	5.9
Congenital lesions			
Meckel's diverticulum	5	1	20
Other	9	3	33.3
Obturation			
Fecal impaction *	7	5	71
Other	6	0	0
Ulcerative colitis	3	1	33
Tuberculosis	3	2	67
Endometriosis	1	0	0
Radiation stricture	7	0	0
Pressure from abscess	3	0	0
Total mechanical obstructions	1000	180	18.0

*Only severe cases included.

B. TOTAL MORTALITY, ACUTE INTESTINAL OBSTRUCTION MASSACHUSETTS GENERAL HOSPITAL, 1947-1955

Cause	TOTAL PATIENTS	DEATHS	MORTALITY, %
Mechanical obstruction	1,000	180	
Mesenteric thrombosis	10	10	
Paralytic ileus *	10	7	
Cause undetermined +	15	4	
Total	1,035	201	19.4%

* Only severe cases included.
+ Subsided on nonoperative therapy or patient died without autopsy.

However, trends are evident, indicating that there has been a gradual reduction in the over-all mortality from this disease.

Comparable figures are available for the past 50 years from the Massachusetts General Hospital. Scudder, in 1907, reported 121 cases, with a mortality of 60 per cent. In 1920, Richardson found the mortality to be 41 per cent. At that time Codman roundly criticized the hospital for permitting patients with this rare and serious condition to be operated on by any other than the chief of service. In 1932, McIver, in an extensive monograph, collected 335 cases, with a mortality of 38 per cent. The next series, reported by McKittrick and Sarris, included 136 cases of small-bowel obstruction (exclusive of early postoperative obstruction), in which the mortality was 20 per cent. In the 1947-1955 series, the over-all mortality was 19.4 per cent (Table 14).

The mortality rates in large series reported in the literature run more or less parallel to these, indicating that there has been a general reduction in the death rate in recent years. While the reported mortality rates vary considerably, it is the belief of the writer that most of the variations in statistics are due to different types of material rather than to more or less effective methods of treatment offered by individual hospitals. Some of the variables that must be considered in interpretation of these figures are as follows:

1). Types of patients and of obstruction.—Hospitals dealing with the very young or very old will have higher death rates. Municipal hospitals that admit a high percentage of derelicts will have less favorable figures than those which deal with private patients who report for treatment without delay.

2). Selection of cases for inclusion in statistics.— Usually there is little difficulty in determining the diagnosis of mechanical obstruction. However, if patients with paralytic ileus are listed, an enthusiastic observer may include many cases that would not appear in the statistics from other institutions. Also, in most hospitals some patients refuse operation for obstruction, are moribund when they arrive, or have obstruction as the final phase of some unrelated terminal disease, so that they are permitted to die, perhaps, without surgical consultation, with unrelieved obstruction. Some statistics include such patients in the over-all death rate; others deal only with patients treated by the surgeon.

3). Selection of deaths due to obstruction.—This is a most difficult factor to interpret. For example, a hospital maintaining care for patients for weeks or months after operation will have a high death rate if all deaths following operations for obstruction from cancer are included. The death rate will be lower in a hospital that keeps patients for only a few days after an

the case mortality rate 18.8 per cent. The patient death rate for acute mechanical obstruction was 18.0 per cent. Nearly half of the deaths were in patients with incurable cancer.

The mortality of treated intestinal obstruction is another important figure. Of the 1,035 patients, 83 had no operative procedure carried out. Of this group, 42 died and 41 survived. The patients who died without operation generally were moribund on entry or had hopeless extension of cancer. The total operative mortality thus was 16.7 per cent.

Representative data from the recent literature are given in Table 15. It is apparent that the mortality in most of the reported series ranged from 10 to 15 per cent. While this is a respectable figure, particularly when it is recognized that about half of the deaths are due to incurable cancer, it is clear that the problems of intestinal obstruction still are far from complete solution.

operation for hopeless carcinomatosis, the patients being discharged to die shortly in nursing homes.

Closely related is the interpretation of deaths. Many obviously are related to treated, but unrelieved, obstruction, while others are due to unrelated causes. For example, death from pulmonary embolism after an operation for acute obstruction generally will be accepted as death due to obstruction. However, if a thoracic aneurysm ruptures after an abdominal operation, death is hardly ascribable to the obstruction. Unfortunately, most immediate causes of death are closely related and it is nearly always impossible to prove that obstruction did not precipitate death from another cause not related to the obstruction. For this reason, to isolate deaths due to obstruction from those which occurred after the obstruction had been relieved is difficult or impossible.

TABLE 15.—Mortality Rate, Acute Intestinal Obstruction

		No. of	Mortality, %			
		Patients	Small	Large	Combined	Note
Becker	1940-1949	205		32.7		Colon obstruction only
			15			Small intestine only
Becker, Davis, and Lehman	1933-1947	406	20.3	21.9	20.4	9 patients admitted moribund
Bollinger & Fowler	1945-1951	205	12.2			Small intestine only
Drugas and Schiff	1945-1950	154	12.3			Small intestine only
Gregg	1949-1951	439	8	12	10	Combined reports of 35 surgeons
Howard	1941-1950	57		7		
Moses	1943-1945	118	8.4			Small intestine only; only 10% admitted within 24 hours
Nemir	1940-1950	379			11.0	Patient mortality rate
Slattery & Ferrato	1940-1954	85		11.7		
Wangensteen	1942-1953	1079			14.5	Patient mortality rate (uncorrected)
West & Schetlin	1939-1949	177	16.3			
Massachusetts General Hospital series	1947-1955	1035	15.4	24.2	19.4	

Comment.—From this brief discussion, it is apparent that an accurate comparison of the data from different institutions is, at the least, a difficult task. The figures from the Massachusetts General Hospital for the 1947-1955 series of cases may be summarized as follows:

The over-all patient mortality rate (1,035 cases, 201 deaths) was 19.4 per cent. The over-all case mortality rate was slightly lower, since 22 patients were treated more than once for obstruction. These 22 patients had a total of 52 separate hospital entries for the treatment of obstruction, making

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